MAY 1956

THE WELDING JOURNAL

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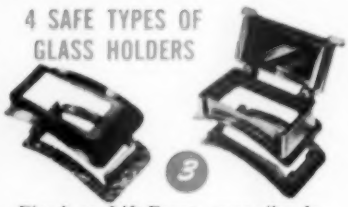

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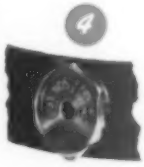

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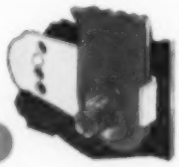

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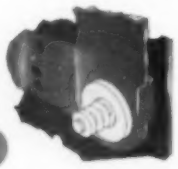

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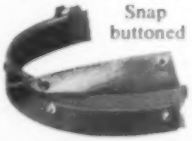

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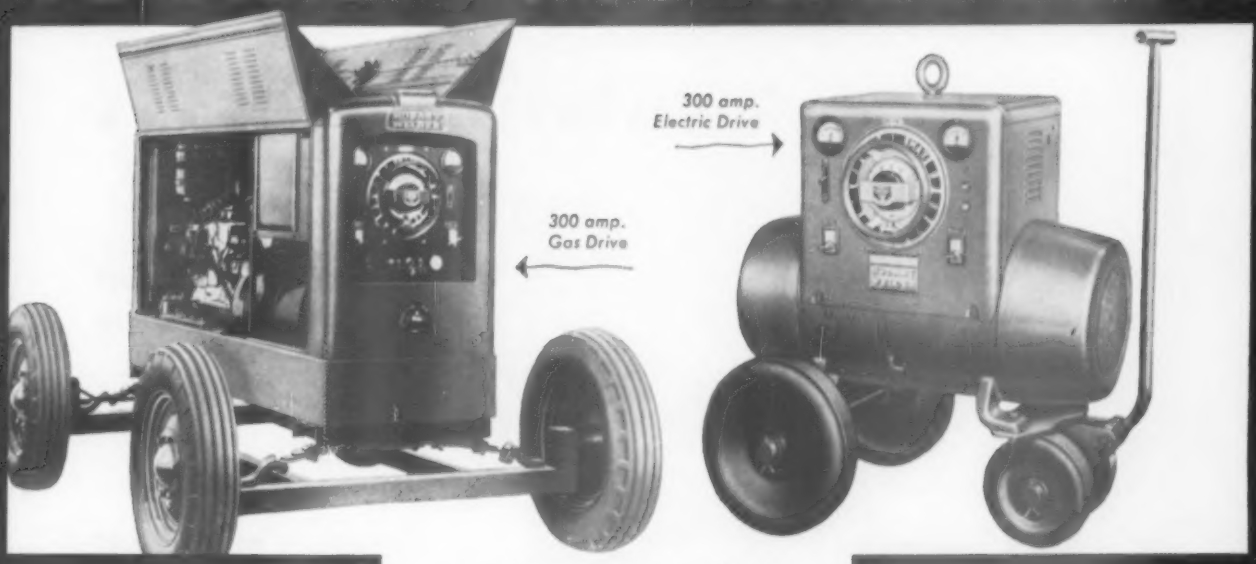

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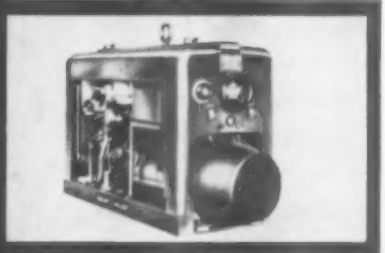

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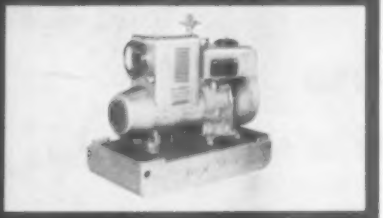

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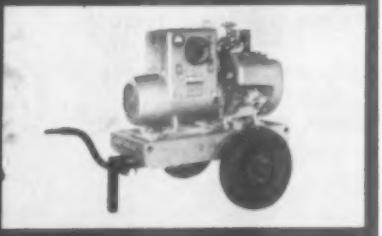

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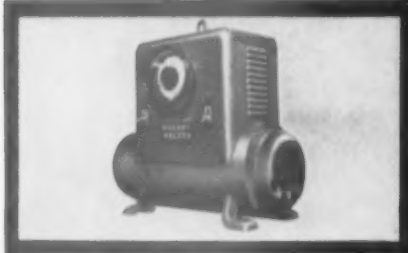

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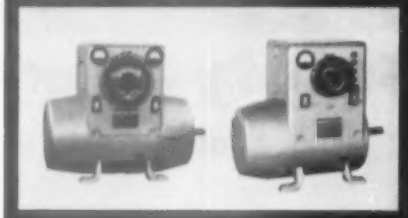

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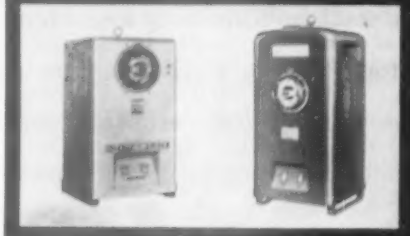

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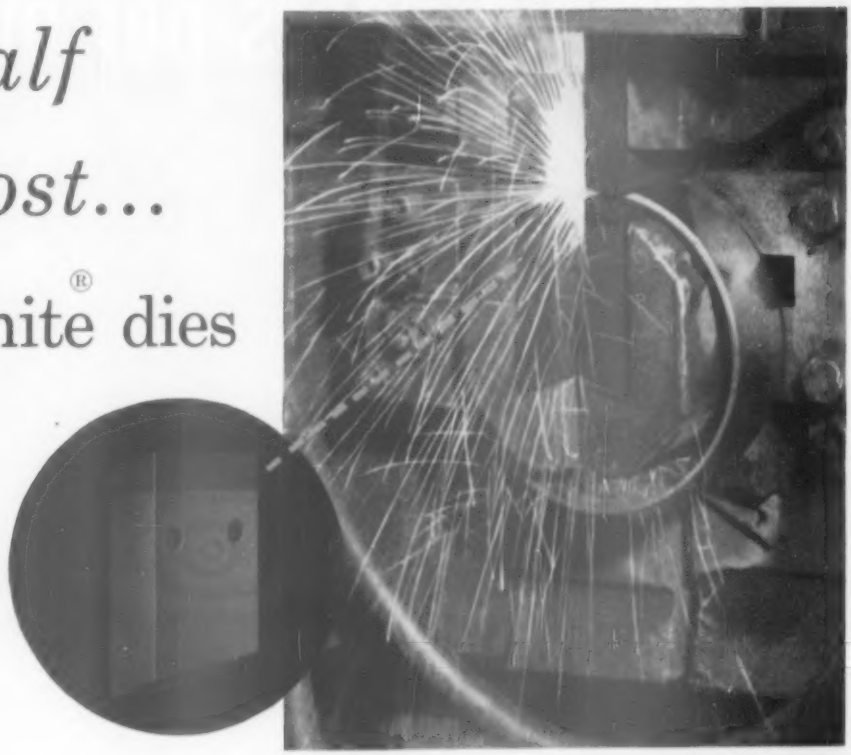

Die insert for this flash and butt welding machine is faced with Elkonite 10W53 . . . a dense, hard material with high resistance to arc erosion, high strength and good electrical conductivity. The backing material is Mallory 53 alloy.

On the flash butt welding of transmission brake bands, a large manufacturer of automatic transmissions has made real improvements in the economy and volume of production . . . by the use of Mallory engineered die inserts faced with Elkonite alloy. Here are the actual production results:

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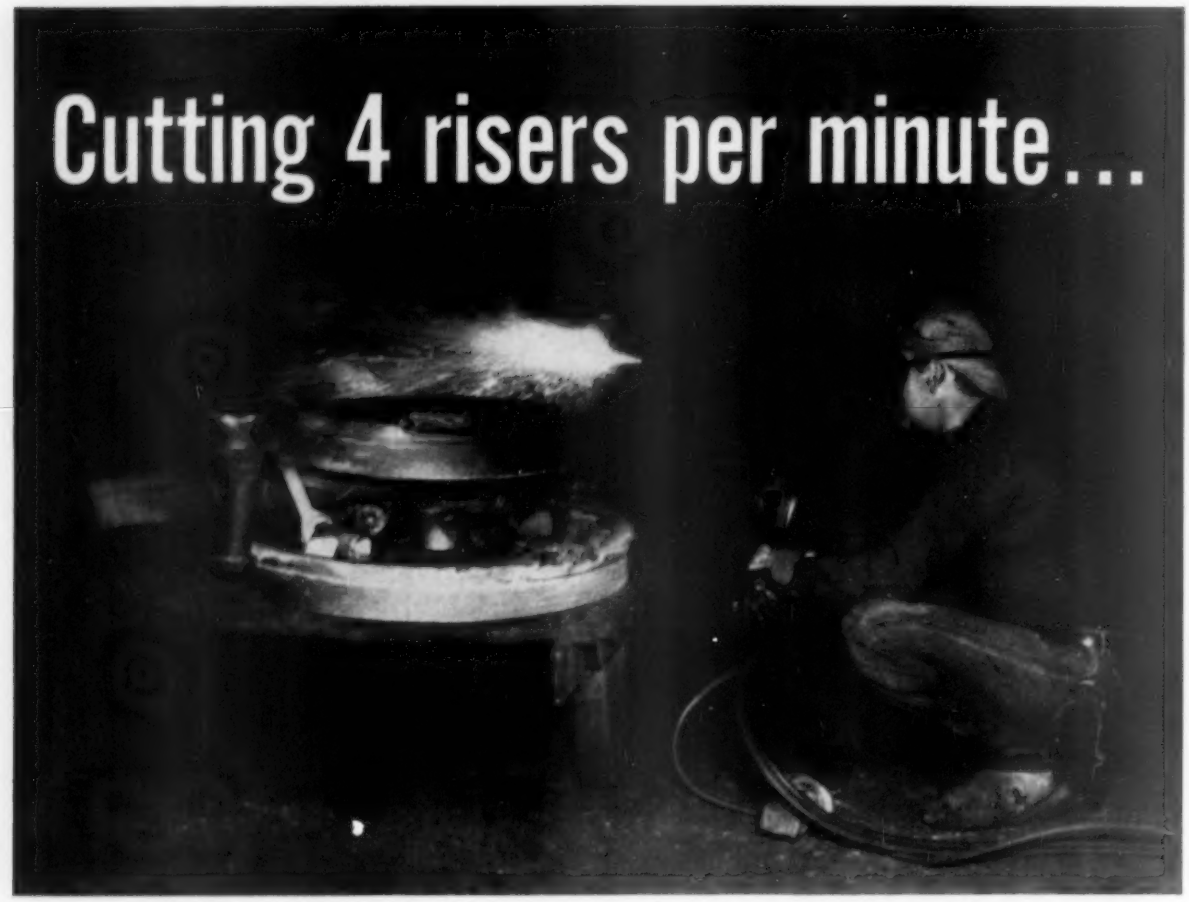
Cutting 4 risers per minute...



Lightweight and easy to handle, this OXWELD powder-cutting blowpipe makes fast work of risers.

Powder-Cutting speeds removal operations 300%

Removing risers from stainless steel castings need no longer be costly and time consuming. Pictured above is a typical powder-cutting operation at the Ohio Steel Foundry Company, Springfield, Ohio. Here, 2 by 4 inch thick stainless steel risers are removed by powder-cutting in only 15 seconds. By methods previously used, this operation took up to four times longer.

In the powder-cutting process metal powder is automatically injected into an oxygen flame to increase the flame's heat and severing action speed. The powder process is helping users gain new efficiency and speed in the removal of gates and risers, sand incrustations, and casting defects.

The powder-cutting blowpipe used in this operation, an OXWELD AC-4, is designed for hand cutting of oxidation resistant metals such as stainless steel, chrome alloys, and cast iron. Heavier apparatus is also available for manual and mechanized operations.

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THE WELDING JOURNAL

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Largest Monel press roll ever built is fabricated by welding three 120" sections of plate together.

Sound from end to end

60 feet of welding in 2¾-inch-thick Monel shows "not the slightest evidence of porosity"

High-speed paper mills pay a pretty penny for every minute of downtime. Yet, with an ordinary suction press roll, they have to ream thousands of holes and refinish the surface as often as every ninety days.

Right now several mills are operating Monel* rolls that have gone *more than three years without being touched.*

Welding a super press roll

Fortunately, fabrication of these super Monel press rolls presents no problem. Even in the case of giants like the one shown here, it's done simply and *soundly* with "130" Monel Electrodes.

This job was handled by the Youngstown Welding & Engineering Company. And it was a big job . . . *but literally!* Three 2¾-inch-thick by 38-inch-wide by 240-inch-long plates had to be joined to form the roll. Together they weighed nearly 12 tons.

700 lbs. of Electrode

The Youngstown people spent 500 hours welding this roll and used 700 lbs. of 3/16 inch diameter "130" Monel Electrodes for the three seams — 60 feet of 2¾-inch-thick weldment!

After each pass they made close inspection visually and with a flaw-detection penetrant. A final check was made by machining the roll surface and boring a little less than half way through the welds at various spots.

No porosity

Youngstown reported this final check "did not reveal the slightest evidence of porosity." Welding with "130" Monel Electrodes had proved a highly satisfactory method of fabricating. The three welds are as strong as the parent metal and *just as corrosion-resisting* . . . that counts in the mills.

Maybe you have a welding job coming up, a job on Monel nickel-copper alloy, Nickel or one of the other high nickel alloys. Use INCO Electrodes for best results. They're easy to work with. Write for the whole story in Technical Bulletin T-2, *Fusion Welding of Nickel and High Nickel Alloys.*

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Joining nearly 12 tons of Monel nickel-copper alloy to form this giant press roll took 500 hours of welding and 700 lbs. of Inco "130" Monel Electrodes.

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OUR INSPECTION PROBLEM

In almost 30 years in the welding industry, I have seen it grow from a comparative infant to a young giant. All of us in welding can point to this as a great record of accomplishment, and we can reasonably assume that we in the industry are progressive and "on the ball."

However, in my opinion, we are now in a crucial period. I believe the industry has reached the point where it should be interested in exploring new fields and taking challenging steps as much as in protecting its reputation.

Let us not lose sight of the fact that welding is a tool as well as a process—as such, it is designed to do a job.

The properties that a weld must possess depend, of course, upon the service conditions to which the structure or weldment is to be subjected. However, there are numerous applications where a sound weld will outlast the usefulness of the product. What is more, in some cases, welds rejected through certain inspection procedures have proved to do the job just as well as similar welds which have passed inspection and have been accepted.

As I see it, one of the principal reasons why welding is proceeding slowly in replacing old, outmoded methods of joining metal parts is that our inspection methods have not necessarily kept pace with industry developments.

There is no reason as to why more bridges should not be all-welded structures. The same applies to similar structures where at the present time the testing and inspection requirements tend to make the use of welding uneconomical.

I am not suggesting a lowering of our standards. I merely wish to point out that our industry today has progressed to the point when we should not let up in our efforts to re-examine the available testing requirements and, where necessary, to revise them to conform to our modern standards.

We in the American Welding Society should continue to take the leadership in this direction and I feel sure that we will. We will not fail to take full advantage of our present knowledge which exceeds, by far, that of the people who wrote testing specifications a generation or more ago.

Let us, therefore, the modern welders, help our country to enjoy the benefits of welding by making sure that our inspection and testing specifications are keeping pace with the progress being made by the science and art of welding.

Niels C. Miller
PRESIDENT
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The appropriate TEMPILSTIK° is selected and, for most applications, the work-piece is marked with it before heat is applied. On subsequent heating the crayon-like mark of the TEMPILSTIK° melts as soon as its temperature rating is reached.

The mark made by a TEMPILSTIK° may gradually change in color as heating progresses. The change in color, or in color intensity, is never to be interpreted as a temperature indication. The TEMPILSTIK° mark melts when its temperature rating is reached and only this change from the dry to the liquid condition is the significant temperature signal.

In some applications this simple method may not suffice because evaporation of the TEMPILSTIK° mark on prolonged heating, or its gradual absorption by the surface at high temperatures, may leave too little residual substance for unambiguous observation. In such cases stroking or touching the work-piece with the TEMPILSTIK° at regular intervals during the heating process is recommended. The TEMPILSTIK° will leave a dry mark at temperatures below its rating and a liquid streak when its temperature rating has been reached or exceeded. If the workpiece is not accessible for applying a TEMPILSTIK° during the heating process, then TEMPILAQ°, or possibly TEMPIL° PELLETS, should be used instead.

TEMPILSTIKS° will usually glide over unheated polished surfaces (like glass, polished stainless steel, etc,) without leaving an appreciable mark. Therefore, in applications that involve smooth or polished surfaces TEMPILSTIKS° should be used by touching or stroking the workpiece periodically during the heating process, as previously described, because a liquid streak will be made on contact as soon as the specified temperature is reached. Where it is necessary to mark a smooth work piece surface prior to heating, TEMPILAQ° should be used.

A hot radiating surface will appear relatively dark under intense illumination from an external source, and this fact can be utilized to improve recognition of the temperature signal against a red-hot background. The use of TEMPIL° PELLETS or TEMPILAQ° instead of TEMPILSTIKS° will further improve visibility under these conditions.

On rapidly moving objects, like magnesium or aluminum sheet during spinning operations, it is impossible to see whether the applied TEMPILSTIK° leaves a dry or melted mark. However, with a little experience operators quickly learn to sense the smooth gliding of a TEMPILSTIK° over a surface which is hot enough to melt it on contact, as contrasted to the frictional drag on a cooler surface. If the top of the TEMPILSTIK° is brought in contact with the moving metal surface for a brief moment at a time, and with light pressure only, the heat contribution of friction is trivial enough to be ignored.

The above described "sensing technique" may also be employed on hot radiating surfaces where the bright background makes it difficult to distinguish whether or not the TEMPILSTIK° mark had melted.

An appropriate series of TEMPILSTIK° marks, applied to the workpiece or surface under investigation before heating begins, will provide a record of the maximum temperature attained during a process or operation. Subsequent examination will show that all TEMPILSTIK° marks up to a certain temperature rating had melted, while those of a higher rating had not. The maximum attained temperature must consequently lie somewhere in the interval between the highest melted and the lowest unmelted TEMPILSTIK° rating.

The temperature distribution and isothermal boundaries of surfaces such as furnace walls, melting ladles, cement kilns, etc., can be established by using an appropriately chosen series of TEMPILSTIKS° to draw a pattern of lines (parallel, concentric, radial, etc.) on the area under investigation. The heat conduction along a surface can be effectively studied by the progressive melting of suitably chosen TEMPILSTIK° lines. Caution must be exercised not to permit the mark made with one TEMPILSTIK° rating to cross or overlap the mark of a dissimilar TEMPILSTIK°, as such a mixing of different TEMPILSTIK° marks would destroy their accuracy.

TEMPIL° products will give good results in induction heating and in ionized air, as well as in the presence of static electricity about electrical equipment, where electrical means of measuring temperatures often function erratically.

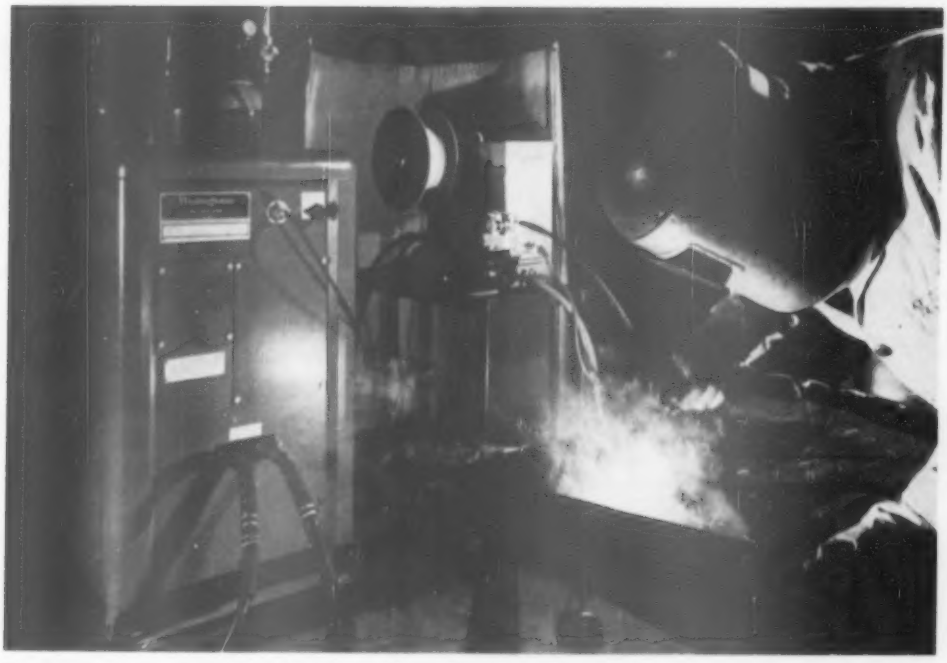

Fig. 1 Constant potential welder, wire drive unit and gun in operation

A STRAIGHT-POLARITY, INERT-GAS PROCESS FOR WELDING MILD STEEL

Straight-polarity gas metal-arc welding process for mild steel made possible by addition of metallic-oxide coating to surface of electrode

BY J. M. CAMERON
AND A. J. BAESLACK

SYNOPSIS. An inert-gas consumable-electrode process for welding mild steel has been developed utilizing the inherent higher deposition rate characteristic of a straight polarity arc. This has been made possible by the application of a coating to the surface of the electrode to stabilize the arc. A brief discussion of arc stabilization and other arc characteristics is included.

Applications of the process and weld characteristics, such as speed, penetration and bead contour are described.

Descriptions of the welding power supply and electrode feeding mechanism characteristics suitable for use with the process are included.

A straight-polarity inert-gas consumable-electrode process for welding mild steel has recently been developed. The basic element of this process is a stabilized straight polarity electrode wire; however, its effective use is dependent on the equipment with which it is used. For this purpose, an integrated line of equipment has been developed consisting of a constant potential rectifier welder, a welding torch and a combined wire drive and process control unit (see Fig. 1). These components working together with the new electrode have helped overcome many of the difficulties encountered in the application of the inert-gas-shielded metal-arc consumable-electrode process in the welding of low-carbon steels.

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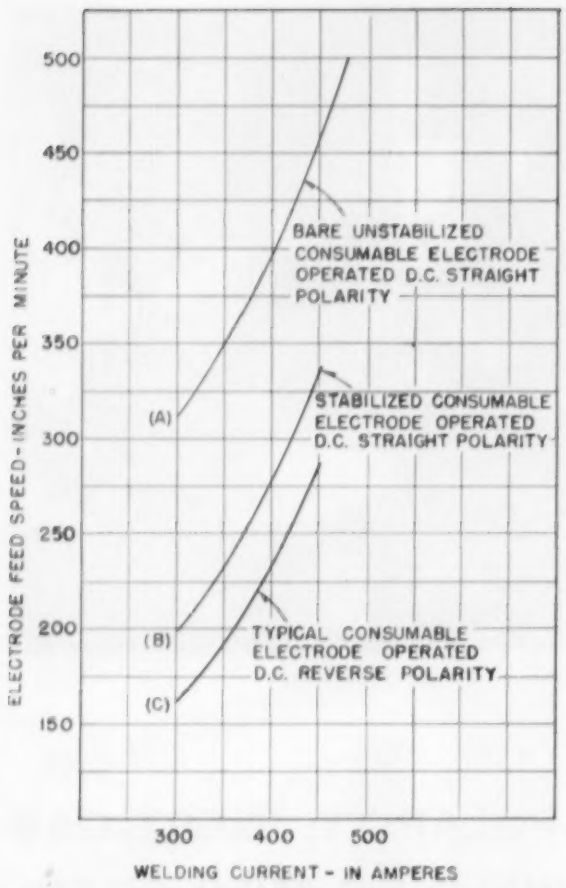


Fig. 2 Metal deposition rates for $^1/_{16}$-in. diam steel electrode in pure (99.8%) argon. Electrode feed speed, ipm, vs. welding current

The high-current density, gas-shielded arc processes are relatively new and their applications have been mostly limited to nonferrous metals. Application of these processes to mild steel welding have been greatly hampered by the quality of the welds obtained and by relatively high costs. It was, therefore, felt that a need existed for a process that could produce high quality welds in mild steels at low cost.

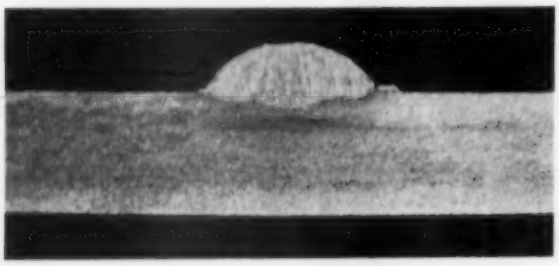
The primary factors effecting the economics of any welding process are material and labor costs as well as weld quality. Factors that affect the quality of a weld made with an inert-gas-shielded process are: Adequate gas shielding, chemistry of the core or electrode wire and the metallurgical properties of the base metal. All of these factors were investigated in the development of this process.

A discussion of the reasons for choosing a straight polarity process follows.

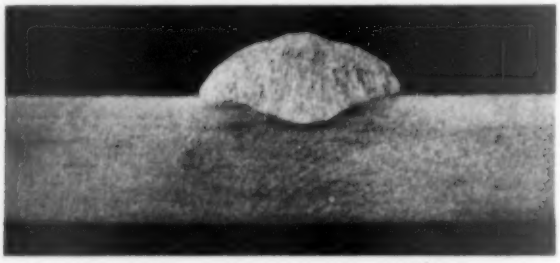
Deposition Rates

One way to reduce inert-gas welding costs is to increase welding speeds. This increase in welding speed is then reflected in both the labor cost and the cost of the shielding gas.

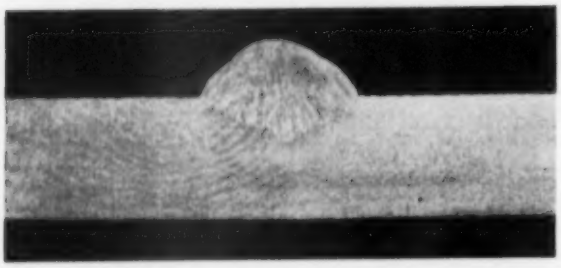
To increase speed and still deposit the volume of metal required for a given joint, it is necessary to increase the rate at which the electrode metal is deposited. Earlier research indicated that a steel electrode in an atmosphere of nearly pure (99.8%) argon had a higher deposition rate when the electrode was negative (straight polarity or DCSP) than when the electrode was positive (reverse polarity or DCRP) at corresponding values of current. Figure 2 shows the relative deposition rates for $^1/_{16}$-in. diam bare steel electrode both for DCSP and DCRP operation in pure argon.



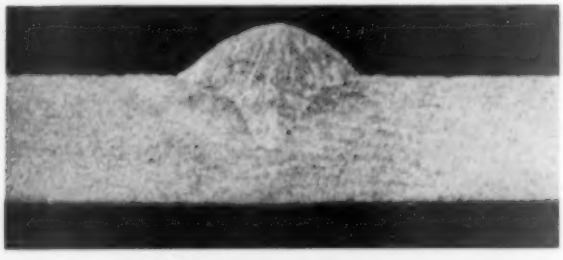
(A) DCSP bare electrode in pure argon



(B) DCSP bare electrode in argon with 5% oxygen



(C) DCSP stabilized electrode in pure argon



(D) DCRP bare electrode in pure argon

Fig. 3 Macrographs showing relative penetration patterns in $^1/_4$-in. mild steel plate for steel electrodes in atmospheres of pure argon and argon oxygen mixtures. Current, 360 amp; travel speed, 30 ipm

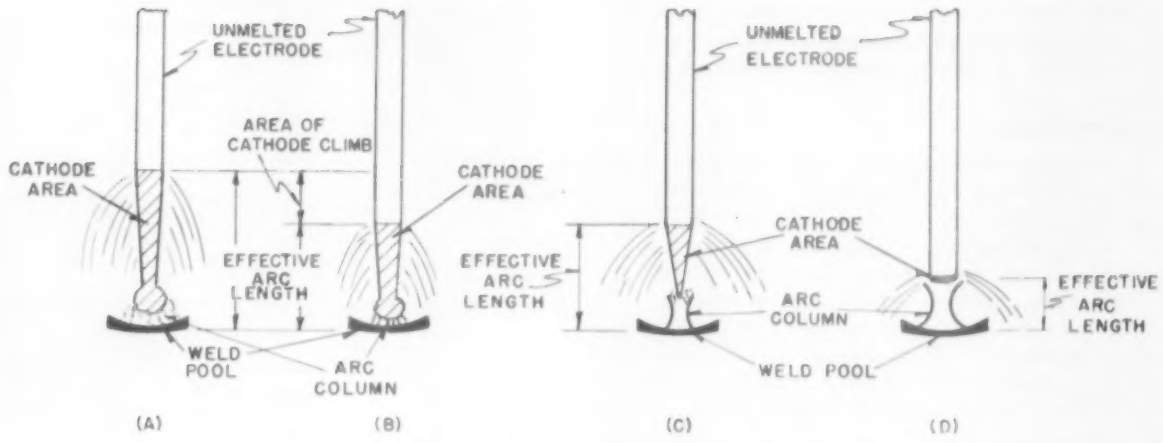


Fig. 4 Appearances of arcs and cathode areas of electrodes for various welding conditions

(A) and (B) illustrate the extremes of cathode area and effective arc length that occur with unstabilized bare electrode operated DCSP in pure argon. (C) Bare electrode operated DCSP in argon containing 5% oxygen. (D) Stabilized coated electrode operated DCSP in pure argon.

Unfortunately, the characteristics of the straight-polarity arc in pure argon and the resultant weld are such that this high deposition rate cannot be fully utilized. A logical area of investigation was suggested, however, since the achievement of high electrode deposition rates was the objective.

Arc Characteristics

The high burn-off characteristic of the steel electrode operated straight polarity in pure argon is of little practical value for two reasons. First, the shallow penetration characteristic illustrated by the photomacrograph in Fig. 3*A* is not satisfactory for many welding applications. Secondly, the arc is highly unstable. This instability is characterized by the tendency of the cathode to wander over the surface of the electrode.[1] This wandering can be observed visually as a movement of the cathode spot up and down the electrode as shown in Figs. 4*A* and 4*B* which show the extremes of travel. Associated with this cathode instability are changes in arc voltage and current that make the arc practically inoperable from a welding standpoint. This arc instability also tends to cause air to mix with the shielding gas so that even high gas flows do not provide effective shielding of the arc.

Thus, before a straight polarity process could be successfully developed, it was necessary to solve the problems of arc instability and inadequate penetration.

The first of these problems, arc instability, was approached on the basis of information gained from earlier research dealing with electric arcs in atmospheres of inert gas. These earlier findings indicated that by the addition of oxygen to the inert-gas atmosphere, a certain degree of cathode stabilization could be achieved. It was found that the addition of 5% oxygen to the argon would give maximum stability with little weld metal oxidation.

The high burn-off characteristic obtained with the straight polarity arc was not materially changed; however, a slight increase in penetration resulted. This is seen by comparing Figs. 3*A* and 3*B*. The results obtained were still not satisfactory for many applications. In addition to the shallow penetration being unsatisfactory, it was found that the arc was stabilized at a relatively high arc voltage. This was due primarily to the fact that the cathode was formed over a relatively large area of the electrode. The electrode then tends to burn off in the shape of a dagger, as shown in Fig. 4*C*. Any attempt to reduce the arc voltage by shortening the arc results in the tip of the dagger extending into the weld puddle and produces considerable spatter as well as severe turbulence in the gas shield. At the same time, the high level arc voltage required for spatter free welds was inconsistent with high speed automatic applications.

Arc Stabilization

Since the results obtained by the addition of oxygen to the arc atmosphere were not entirely satisfactory, additional development was indicated.

The problem of arc stabilization is one as old as the welding industry itself, and is normally solved by the addition of certain metallic oxides in the coatings of manual electrodes. When a suitable combination of metallic oxides was applied to the surface of an electrode to be used in an inert-gas straight-polarity process, satisfactory results were obtained. The arc characteristics resulting from this type of stabilization differ greatly from those described previously for the unstabilized straight polarity arc in pure argon or the argon-oxygen stabilized arc. In contrast to either of the above arcs, the metallic oxide stabilized arc is characterized by a definite isolation of the cathode to the end of the electrode as shown in Fig. 4*D*. Because of this characteristic, it is possible to operate at very low arc voltages with short arcs and a minimum of spatter, thus making the process adaptable to high speed applications where these characteristics are required. The process is further characterized by a quiet running arc and due to the confinement of the

cathode spot to the end of the electrode, little turbulence is produced in the shielding gas. This fact tends to account for the low shielding gas requirement of the process.

Energy Distribution

Further advantages are achieved by the addition of these metallic oxides to the surface of the electrode. It is possible by the proper selection of materials to change the energy distribution in the arc. That is, a large portion of the energy in the arc can be concentrated at the cathode to produce high burn-off rates or more of the energy can be transferred to the work, producing deeper penetration. When control of the energy distribution is achieved, it is a matter of choice as to which combination of characteristics is desired for a particular application.

Control of Weld Quality

It is believed that the main factors affecting weld quality in an inert-gas process are: (1) adequate gas shielding, (2) proper core wire chemistry and (3) minimizing base metal dilution where low-grade or rimmed steels are involved.

The first of these is primarily dependent upon the design of the welding gun and the minimizing of turbulence in the arc. The second, core wire chemistry, is important since the only method of deoxidizing the weld metal is by means of the deoxidizers in the core wire. The third is achieved by controlled penetration. Figure 5 illustrates this point for rimmed steel. If a penetration pattern similar to that of 5*A* can be achieved very little dilution of the weld metal with the core impurities will take place. Since the rim is relatively pure iron, sound, porosity-free welds result. However, in the case of a penetration pattern of the type shown in Fig. 5*B*, excessive penetration into the core occurs and the impurities in the core dilute the weld metal producing a potentially poorer weld. It is, of course, realized that the thickness of the rim varies from steel to steel and it is not practical to attempt to match rim thickness with electrode characteristics. This illustrates, however, that the percent dilution of the weld by the core on even thinly rimmed steel would be less for a controlled penetration electrode than for a deeply penetrating electrode.

Results

This study has resulted in the commercial production of an electrode having burn-off characteristics as shown by curve *B* in Fig. 2, and penetration as shown in Fig. 3*C*. The burn-off rate is somewhat above that of the reverse-polarity electrode, while the penetration pattern is shallower than that of the reverse-polarity electrode. This combination of characteristics was chosen as a good compromise between high burn-off and deep penetration.

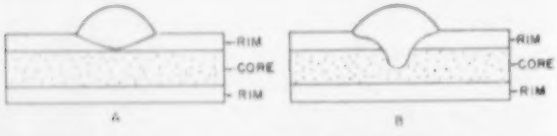


Fig. 5 Effect of penetration pattern on dilution in rimmed steels

(A) Weld made with stabilized electrode operated DCSP does not penetrate into core. (B) Weld made with bare electrode operated DCRP penetrates into core.

Table 1—Process Data for Welding Refrigerator Compressor Housing

	Reverse polarity process	*Straight polarity process*
Current, amp	360	360
Arc voltage, V	28	24
Shielding gas	Argon with 5% oxygen	Argon with 2% oxygen
Gas flow rate, cfm	40	20
Welding speed, ipm	53	53
Rejects, %	5 to 8	<1

Table 2—Weld Metal Physical Properties

Temperature, ° F →	*+80*	*0*	*−100*	*−200*
Yield point, psi	63,200	81,700	90,000	109,200
Tensile strength, psi	76,000	92,400	100,600	111,500
Elongation, % of 2 in.	27.9	25.85	25.50	27.13
Reduction in area, %	69.4	69.90	61.30	57.90
Impact,* gas metal-arc, DCSP ft-lb	100.0	80.0	22.0	...
Impact,* E6020 Manual, ft-lb	58	25	21.0	...

* V-notch Charpy impact test.

The welding of rimmed steel has been discussed in detail because of the special problem involved, however, the process is applicable to killed and semikilled steels with good results.

Equipment

The successful application of this welding process is dependent on the characteristics of the electrode wire driving unit and the welding current supply. The combination of a rectifier constant-potential welder and a wire driving unit to feed wire into the arc at a constant preselected speed is particularly well suited to the process. Independent adjustments of the arc voltage and the arc current are made possible by the relatively flat volt-ampere characteristic of the constant-potential welder. Arc current is automatically regulated by the rate at which the wire is fed into the arc, while the arc voltage can be set by adjusting the welder voltage.

Rectifier welders having low inductive circuits, voltage drops of about 1.2 volts per hundred amperes and having a wide range adjustment are excellent for this process. The inherent high short circuit currents and fast speed of response of this type of welder produces an extremely forceful and stable arc having good starting characteristics.

The electrode wire driving unit must have a wide range of speed adjustment and be capable of maintaining a constant speed regardless of fluctuations in load on the motor. These characteristics are necessary since the welding current and metal deposition rate are direct functions of the wire speed. In addition, special attention must be given to the starting and stopping

Fig. 6 Residential refrigerator compressor housing

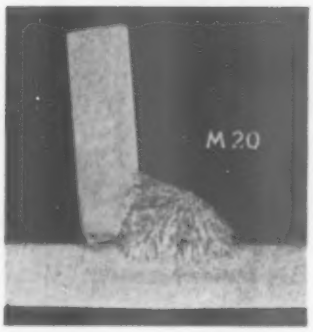


Fig. 7 Macrograph of a typical fillet weld in $^1/_4$-in. thick mild-steel plate

characteristics of the electrode wire drive unit. "Burnbacks" will result from a slow start after the arc is struck or from too rapid deceleration of the wire when the weld is stopped. A delay in stopping the wire at the end of a weld can cause the electrode wire to freeze to the weld. Dynamic braking of the wire drive motor provides a convenient method of controlling the deceleration of the wire at the end of a weld.

The welding gun is also an important component. It must be designed to guide the electrode wire, introduce the welding current into the electrode and direct the inert gas shield evenly around the arc. Good gas coverage is of prime importance, and it is achieved with relatively low gas flows in this welding process due to the stabilizing effect on the arc of the wire coating. Semiautomatic hand welding guns should also include the operator's controls.

Application

An application demonstrating some advantages of this straight polarity process over a reverse polarity process is the fully automatic welding operation on the residential refrigerator compressor housing shown in Fig. 6. The joint is a lap weld. Comparative data for both processes is given in Table 1.

The material to be welded is 0.078-inch thick, deep-drawn rimmed steel. The work is fixtured and rotated at an angle of 45 deg from the horizontal with the torch located in a vertical position directly above the work. The same welding speed was used for both processes since the fixture was driven by a constant speed motor. Although the same current of 360 amp was used in both cases, the straight polarity process deposited more metal and produced a wider bead. This made the fit-up less critical. Penetration was another factor that reduced the occurrence of rejects with the straight polarity process. The more shallow penetration occurring with the straight polarity process reduced the tendency to burn through the thin wall section. It also reduced the dilution of the weld metal by the core metal of the rimmed steel. Another advantage is the 50% reduction in gas consumption. This can be attributed to the quiet arc characteristic and the effective gas coverage provided by the welding gun.

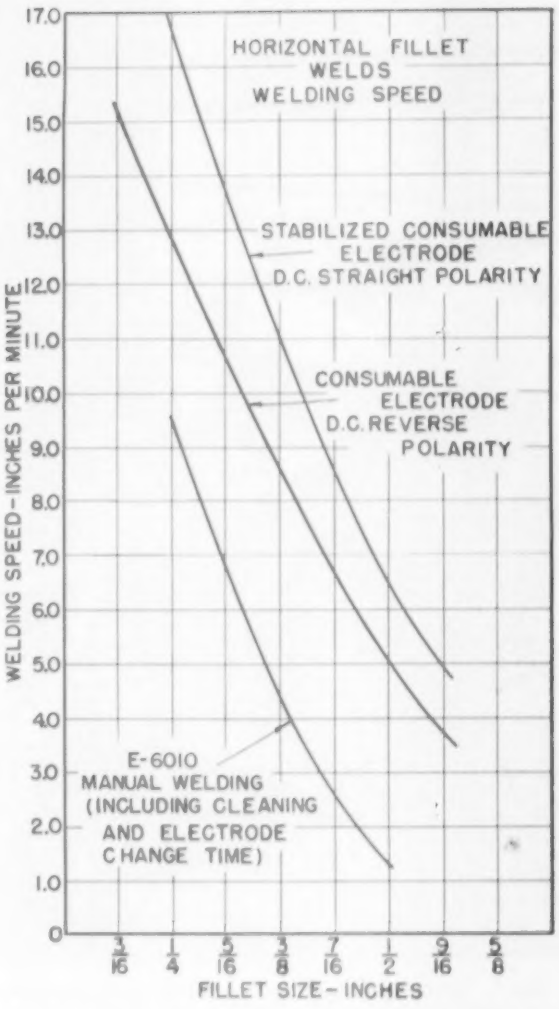


Fig. 8 Comparative welding speeds for horizontal fillet welds

A typical fillet weld on $^1/_4$-in. mild-steel plate is shown in Fig. 7.

A study of the relative welding speeds of this process as compared to welding speeds obtainable from a reverse-polarity consumable-electrode process and from a manual stick electrode are shown in Fig. 8.

Physical properties of deposited weld metal are given in Table 2.

Conclusion

It has been shown that the addition of a coating of metallic oxides to the surface of a steel electrode wire for inert-gas consumable-electrode welding has led to the development of a straight-polarity welding process for mild steel. This process is suitable for semiautomatic, fully automatic and plug welding, and is characterized by high metal deposition rates, good penetration and good arc stability.

Reference

1. Lodwig, H. C., "Cathode Instability in Argon Atmospheres", Mimeographed Conference Paper A. I. E. E. Electric Arc and Resistance Welding IV July (1954).

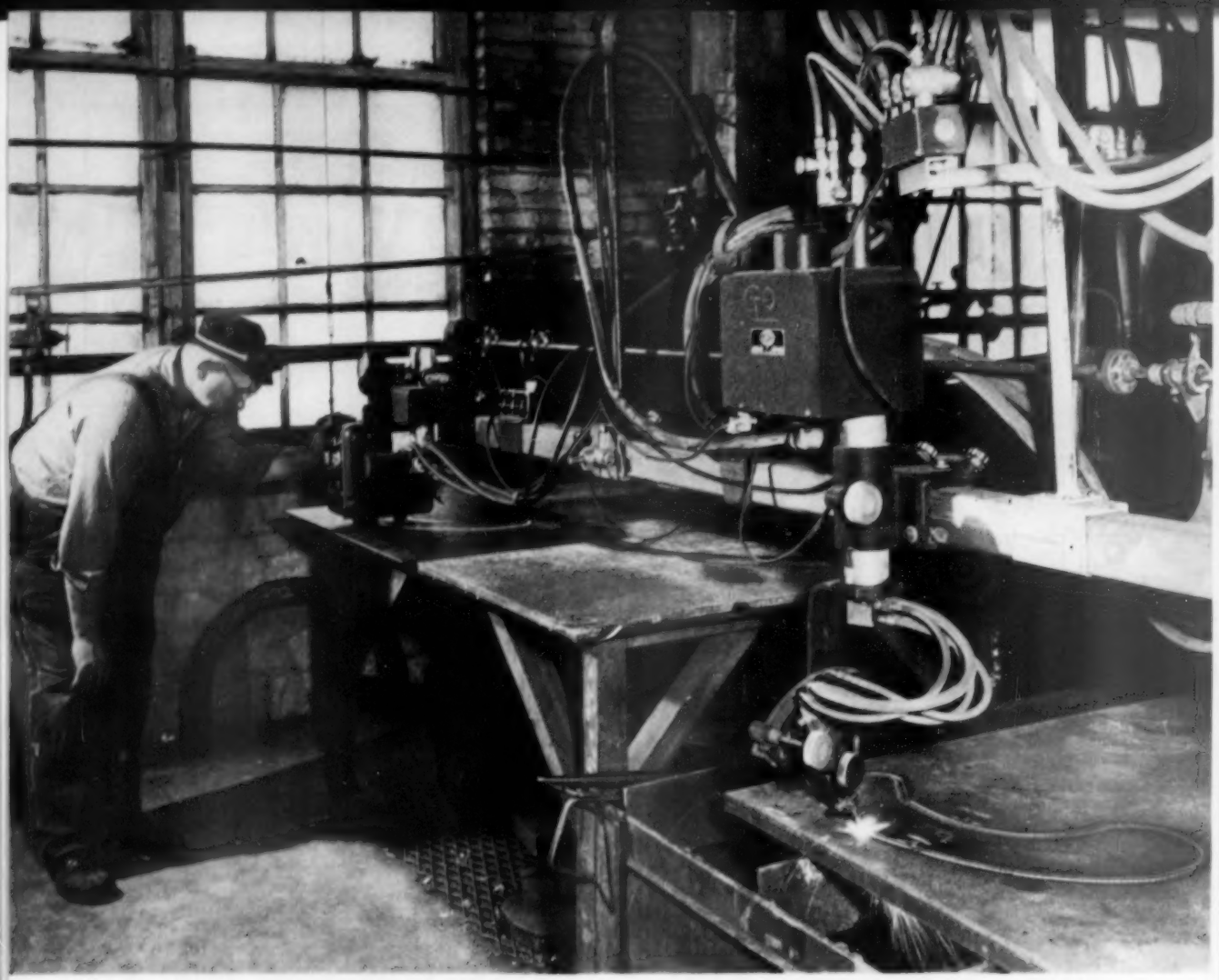


Fig. 1 Contour beveling device installed on a pantograph-type flame-cutting machine

CONTOUR BEVELING WITH THE ELECTRONIC TRACER

BY HOWARD CARY AND R. F. HELMKAMP

Automatic contour beveling with electronic tracer tends to reduce handling and subsequent operations in preparing gas-cut sections for welding assemblies

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Presented at 1955 AWS National Fall Meeting held in Philadelphia, Pa., October 17–21.

Introduction

Contour beveling with the so-called "electronic tracer" is in the early stages of successful commercial practice. It has grown out of the development of the flame-cutting process as a production tool and its mechanization for straight-line and shape-cutting of steel plate with squared edges. The increasing use of irregularly shaped steel weldments requiring beveled edges for full penetration welds focused attention on the need for automatic contour flame-beveling equipment.

In short, automatic contour flame beveling eliminates additional materials handling by accomplishing the desired bevel for an irregularly shaped steel weldment

while performing the original pattern cut. This means that the straight edge cut on irregular steel shapes need not be followed by additional handling for layout, setup and a separate beveling operation.

The need to eliminate what is obviously extra handling of material can long be apparent before equipment and techniques are available to meet the need. Pioneers in the use of flame-cutting equipment for contour beveling have, until recently, been faced with a production need for which there was no standard equipment. They tackled the job in their own way with the help of specialists in the welding and cutting field.

Contour flame beveling of bridge expansion joints, for example, was accomplished for the first time on a mechanized basis several years ago. Originally, these expansion joints had a $^1/_4$-in. opening—slot, top and bottom. Bridge engineers wanted a self-cleaning slot with a taper. While the straight edge slot did not require a revolving torch, the tapered slot did because of the irregular nature of the expansion joint. Equipment assembled for this job involved a manual tracing device and a torch holder modified to hold a special tip with built-in angle for the bevel required. This mechanized contour beveling device—with a mechanical link between the tracing device and the torch itself—was an important step forward in the development of current automatic contour beveling heads. An arrangement of this type, however, was confined to the use of the hand tracer. Moreover, the bevel on the expansion joint had no relationship to a welded joint.

The greater use of the welded joint, along with the development of the electronic tracer, have given greater impetus to the development of automatic contour flame beveling. Flame-cut weldments requiring beveled edges are being used increasingly for many of the major structural components of heavy machine equipment. The problem was not how to get a bevel on an irregular shape, but how to get it automatically while cutting the steel pattern the first time, thereby eliminating handling for layout, setup and an additional beveling operation after the straight edge cut.

Desire and Need for Contour Beveling Equipment

At Marion Power Shovel, where the use of welding and allied processes has grown as fast as the welding industry itself, recent investigations of the problems concerning weldments subjected to dynamic loadings have indicated the need for complete weld penetration at the welded joints. Full weld penetration with any but sheet steel obviously required edge beveling. Complete penetration weld joints are specified more and more for shovel component weldments which increase the volume of bevel flame cutting required. Following is a description of the flame-cutting sequence at this plant which focused attention on the elimination of extra material moves and led to the adoption of automatic contour flame beveling:

Electric eye chain flame cutting* produces most of the irregularly shaped parts making up the weldments. Parts produced by the chain burning method are square edge cut or blanked. It was found that automatic chain burning with subsequent beveling using portable, semiautomatic equipment is less costly than working to layouts and initially cutting bevels with portable equipment.

Square edge cuts are obtained with automatic burning equipment whether the electronic tracer or other types of tracing devices are used. Thus, parts square edge cut that require a beveled edge must be further processed. Of necessity, the parts that require beveling or further processing in the preparation department must be separated from those not requiring additional processing. The parts needing additional work are routed first to a layout area and then to the flame-cutting area.

At the layout area, parts are checked against blue prints and layouts are made on an individual basis for the pieces required, indicating bevel type, angle, location and other specifications. This process requires handling and moving parts that require bevels—three times as against only once for parts not requiring bevels.

The ever-present need to reduce manufacturing costs focused attention on these extra material moves. In an effort to reduce the cost of extra handling, an attachment was suggested that would automatically flame-cut bevels on parts of irregular contour. It was requested that this device would work with the electronic tracer and be keyed to the templates to provide beveled edges where desired.

General Equipment Description

Before going into specific job applications, a general equipment description and some of the principles involved in contour beveling with the electronic tracer should be set forth:

Contour beveling is done with special attachments operating single or multiple torches on present standard equipment resulting in a constant and continuous bevel on an irregular contour. The torch is mounted on a segment of a circle so designed that the projection of the center of the cutting tip intersects the center line of the verticle revolving support member at the layout control point of the material to be cut. Open or closed bevels may be cut. The torch need only be revolved 180° to change the setting from an open to a closed bevel. Templates are as simple as for square edge cutting provided the layout is considered the bottom of the bevel.

A bevel around an entire contour requires one 360° revolution of the torch. This is accomplished electronically. A synchro-transformer picks up the direction signal from a synchro-transmitter in the electronic tracer as it progresses around the template. The torch is revolved by a motor according to the signal received from the synchro-control transformer. The torch revolution is in unison with that of the tracer drive wheel and provides a constant bevel at a preset angle on the contour traversed.

* Cary, Howard, "Advanced Automatic Flame Cutting for Machinery Weldments." THE WELDING JOURNAL, 32 (10), 957-965 (1953).

Application of Equipment for Low Volume Production

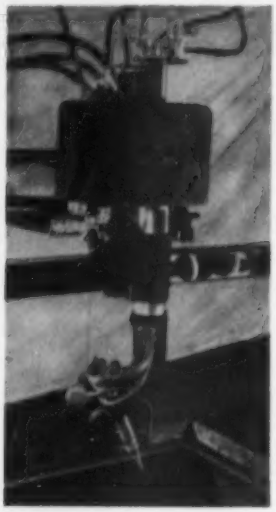


Fig. 2 Close-up view of attachment clearly revealing segment arrangement for setting bevel angle of the torch

Figure 1 shows the contour beveling device installed on a pantograph-type flame-cutting machine. Figure 2 shows a close-up view of the attachment clearly revealing segment arrangement for setting bevel angle of the torch.

Preliminary experimental cutting with the apparatus indicated the need for establishing certain operating conditions. The most important was that the templates for the electronic tracer referred to the top of the cutting table (or underside of the plate being cut) regardless of the thickness of the material or the bevel angle. The axis of the vertical revolving torch holder tube follows the identical path of the automatic tracer. When the torch is in the vertical position, it follows this same pattern and makes a squared edge cut. As the torch is tilted for bevel cutting, it is important that the axis of the torch intersects the axis of the vertical torch holder tube at the top of the burning table.

In adjusting for various thicknesses of material, the torch must be moved along its axis in the torch holder rather than move the vertical tube up or down. By maintaining the intersections of the axes at the lower face of the material being cut, the same templates for square edge cutting can be used for bevel cutting without dimensional changes . . . the toe of the bevel being at the same location as the square edge. Sharp corners must be avoided on all but very thin plates or unless the bevel angle is quite small. The flame path on the top surface of the plate being cut becomes greater as bevel angle and plate thickness become greater. Thus, if the radius is too small, the cut will be extinguished because travel speed is too high.

Obviously, cutting conditions such as oxygen pressure, travel speed, tip size and other factors must be determined according to the thickness of the cut, not of the material. Figure 3 shows parts being flame cut

Fig. 3 Parts being flame-beveled from $1^1/_4$-in. thick material

Fig. 4 Beveling attachment in process of cutting piece from $^5/_8$-in. thick material

Fig. 5 Another view of beveling attachment shown cutting contour piece from $^5/_8$-in. thick material

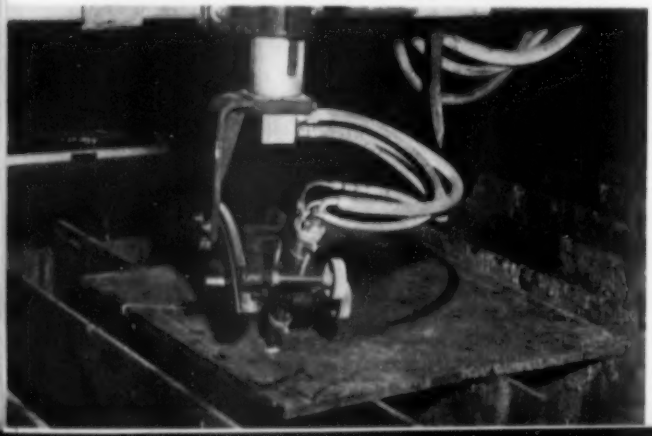


Fig. 6 Completed bevel-cut piece is shown adjacent to plate from which it was flame-cut

from 1 to $^1/_4$-in. thick material. Thinner material is also readily cut. Figures 4 and 5 show the beveling attachment at various stages cutting a piece from $^5/_8$-in. material. The resulting piece and scrap are shown in Fig. 6. Figure 7 shows a template and the resulting piece made from $^1/_2$-in. thick steel. In all of the foregoing cases, the bevel angle was 30° around the cut.

The design of the equipment is such that the vertical tubular torch holder revolves the same as the driving wheel on the tracer and thus always cuts a bevel. On pieces where the bevel is not required, the torch is tilted up until its axis is vertical. Weldment design is extremely important in order to utilize the contour beveling equipment to its best advantage. Beveled edges should be restricted to the least number of pieces in the weldment. However, pieces requiring any bevels may be beveled extensively. Bevel angles must be held constant and should all be from the same side of the piece. Sharp inside corners should be avoided but outside corners can be obtained with proper manipulation of templates.

Application of Equipment for High Volume Production

A unique multiple-torch contour beveling and contour welding installation at the Walsh Construction Co., Portland, Me., points up some of the remarkable production techniques of which modern industry is capable, and underscores the relationship between contour beveling and contour welding on a high volume production job.

Until recently, automatic machine welding has been of the straight-line variety. Automatic contour or shape welding is now an accomplished fact in commercial practice.

At Walsh Construction, automatic contour welding on steel casings, four at a time, preceded by automatic contour beveling, is an industrial example of things to come in the synchronized use of welding and flame-cutting tools. It is also an outstanding example of the adaptability of welding and flame-cutting equipment to automation which reduces materials handling, labor costs and speeds production.

The production sequence is accomplished on a pentagonal table with five stations, resulting in an unprecedented production rate. The speed of the operation requires a high degree of accuracy in the automatic positioning of the casings for both contour beveling and contour welding.

The installation makes use of four contour beveling heads at one station and four automatic inert-gas-shielded metal-arc welding heads at another, each series of four being mounted on a pantograph-type flame-cutting machine. The machine barrels of the four automatic heads are mounted on the operating bar of the cutting machine. The head motors are stationary above the cutting machine. An electronic tracer guides the four beveling heads on one cutting machine, while a magnetic tracer guides the four inert-gas metal-arc welding barrels on the other.

Fig. 7 Template is shown next to resulting piece made from $^1/_2$-in. thick steel. Bevel angle is 30 deg around the cut

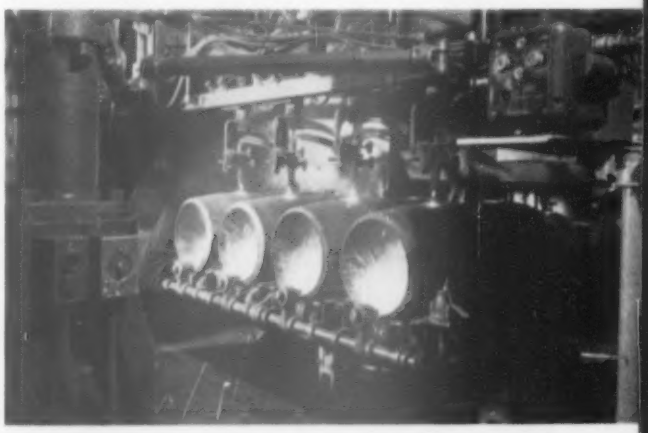


Fig. 8 Contour flame beveling is in process on four steel casings at a time. Cutting speed is 15 ipm

Welding speeds average 15 ipm, as do the flame-cutting speeds, so that once the production sequence is in full operation both welding and cutting go on simultaneously on different sets of four casings without one operation delaying the other. Here is the sequence after the steel casings come off a roll conveyor system and are placed on the pentagonal table:

Four steel casings—16 in. in diam by $^3/_8$-in. wall—are loaded manually at the first station, locked in position and starting holes drilled. The pentagonal table is then indexed to the second station where the lug holes in the casings are flame cut, four at a time, with 20° bevel. One hole is 3 in. in diam while the other is a 3- by 11-in. oblong hole. These holes are designed to receive insert lugs which facilitate the eventual handling of the finished casings by special equipment. Figures 8 and 9 show the contour beveling in progress. Figure 10 shows completed bevels in $^3/_8$-in. thick steel casings.

After the beveled cuts are made in the casings, the pentagonal table is automatically indexed to the third station. Here the insert lugs and combination insert

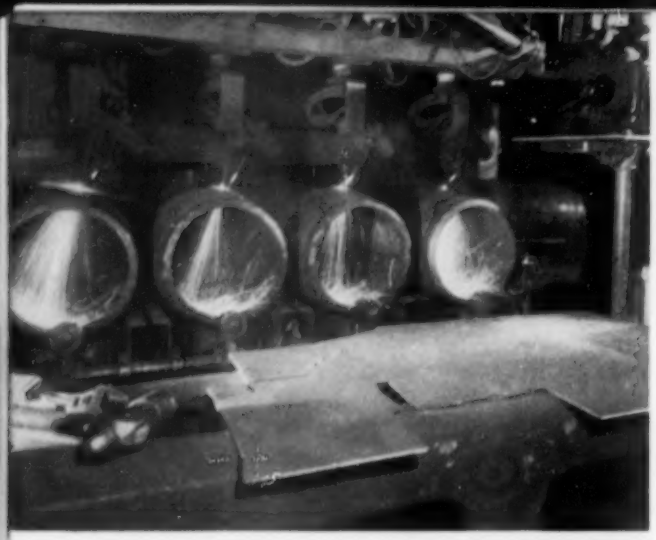


Fig. 9 Another view of contour flame beveling with four beveling barrels mounted on the operating bar of a pantograph-type shape-cutting machine

lugs are positioned mechanically and tack-welded manually with stick electrodes in preparation for automatic contour welding. The insert lugs are steel forgings with a 20° bevel so that when they are positioned into the casings a V groove is created, providing an excellent joint for automatic contour welding. Contour beveling such as this demonstrates forcibly the reduced handling in preparing flame-cut sections for welding.

After tacking at station three, the pentagonal table is automatically indexed to the fourth station where the four welding heads—using argon plus 2% oxygen as a shielding gas—weld the insert lugs which had been tacked into the lug openings. Figure 11 shows four welding heads in action Figure 12 shows another view of station four. Figure 13 shows completed welds. Note the machined "blind" holes in the lugs which facilitate eventual handling of the finished casings with special equipment designed for the purpose.

Fig. 10 Completed bevels made in $^{3}/_{8}$-in. thick steel casings

The pentagonal table is indexed again and releases the four casings to a roll conveyor where they proceed to heat treatment. As the casings move along the roll conveyors there is a slight pause at the preheat station. Here the casings are subjected to open-gas flame for preheat of the weldments as a precautionary measure to the heat-treat process.

Conclusions

Automatic contour beveling with the electronic tracer is a new development designed to reduce handling and subsequent operations in preparing gas-cut sections for welding assemblies. In addition, it opens up greater possibilities for automatic contour welding.

While the economics of its use are questionable on job work and short runs—setup, for example, is time consuming on jobs that are intermittent—substantial advantages are obtained on production work of a repetitive nature. It offers decreased handling, decreased secondary handling and greater uniformity of bevels and joints. In short, it offers users lower costs, improved delivery and a better product.

Moreover, industry today is progressing into fabrication schemes which involve contour welding. Preparation of the joint by automatic contour beveling is essential to achieve the best economies for this type of production work.

In summing up, once again we can say that yesterday's challenge is today's accomplishment. On volume production runs where the beveling requirement is constant and repetitive, we have seen how easily the operation is accomplished. We also have seen that where requirements are not constant it is possible to obtain automatic beveling on contour cuts keyed to templates in such a manner that on edges requiring beveling the templates will be so marked and the torches will automatically cut the bevel.

In connection with production work where bevel requirements are not constant or where varying degrees of bevel are required, engineering design studies that simplify some of the present bevel requirements would be of tremendous advantage to industry. Work with engineering design is sure to produce simplified bevel requirements. Many pieces now call for bevels of varying degrees. A constant requirement is a big advantage on production work.

In general, then, we have another impressive example of the way flame cutting and welding tools are playing very strong roles in significant, cost-saving production trends, demonstrating a high degree of adaptability to mechanization and automation, along with a growing versatility of application in their own right.

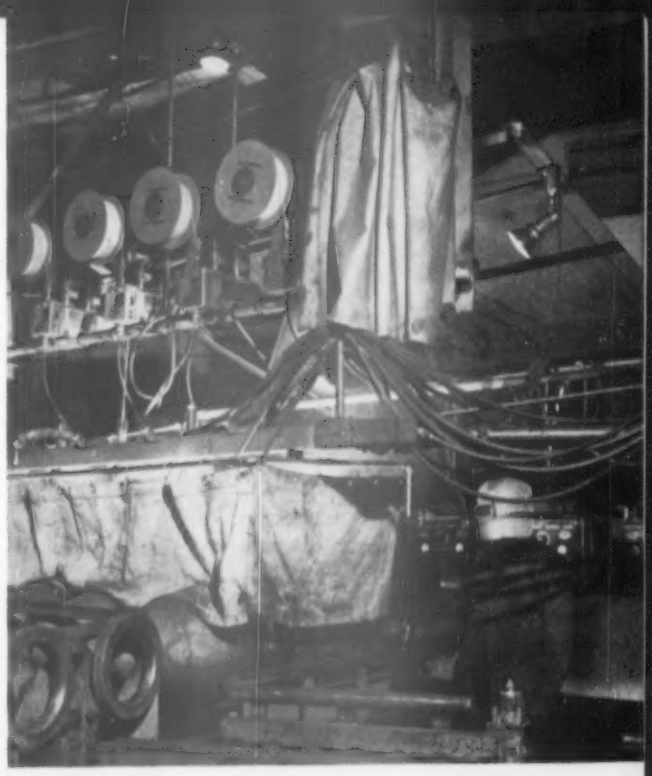


Fig. 12 Another view of four automatic welding heads used to contour weld four steel casings at a time

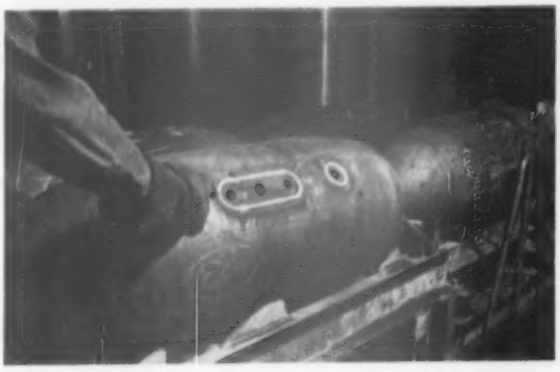


Fig. 13 Completed welds on steel casing

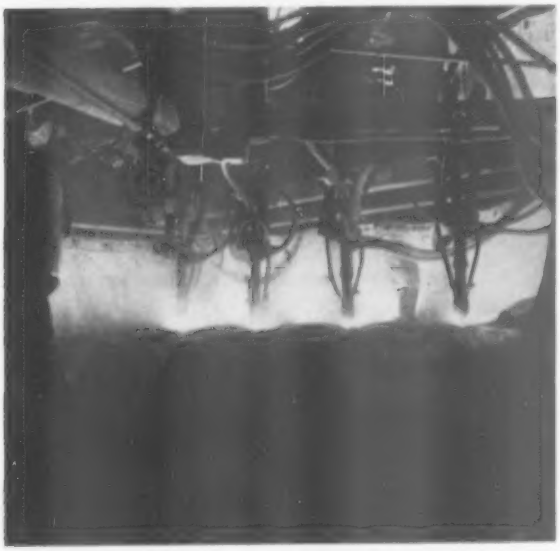
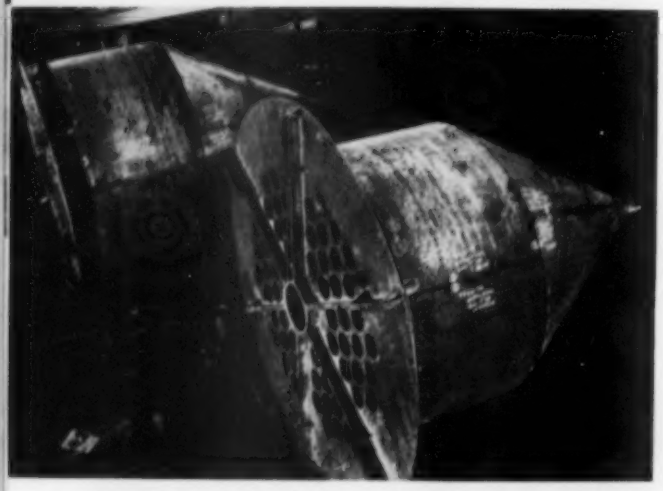


Fig. 11 Four automatic welding heads in action on four steel casings at Walsh Construction Co., Portland, Me. Welding speed is 15 ipm

SOME ASPECTS OF THE METALLOGRAPHY OF STAINLESS STEEL AND STAINLESS-STEEL WELDMENTS



These 12-Cr steel multiclones are used to separate catalyst from oil refining stock

Differentiation of the several micro-constituents of stainless steels can generally be accomplished with certainty, provided that several etchants are used in turn

BY G. V. SMITH

The American Iron and Steel Institute recognizes some 35 different grades of stainless steel, the principal types of which are listed in Table 1, divided into three basic groups:

1. Chromium base (quench hardening or martensitic). These range from 11 to 18% chromium with carbon increasing with chromium content.
2. Chromium base (nonhardening or ferritic). These contain from 11 to 27% chromium with relatively low carbon.
3. Chromium-nickel base (austenitic). These contain 16 to 26% chromium and 6 to 22% nickel, and remain substantially austenitic.

To these several bases may be added various other alloying additions singly or in combination for special purposes:

1. Molybdenum to improve strength at elevated temperatures and to enhance resistance to certain types of corrosion.
2. Titanium or columbium and tantalum to preclude intergranular corrosion.

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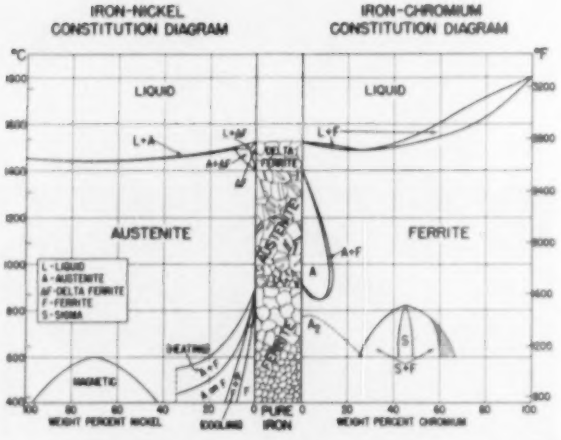

Fig. 1 Iron-nickel and iron-chromium constitution diagrams. Aborn[1]

3. Silicon to improve resistance to oxidation and carburization.
4. Aluminum to reduce quench-hardening of chromium-base steels.
5. Copper to resist corrosion by sulfuric acid.
6. Sulfur, selenium or phosphorus in combination with zirconium or molybdenum for improved machinability.

Constitution

To provide a background for discussion of the metal-

Table 1—Principal Types of Stainless Steels. Aborn[1]

Class	AISI type	% C	% Cr	% Ni	% Other elements
Chromium base quench-hardening martensitic	410	0.15 max	11.5–13.5	...	...
	420	0.16 min	12.0–14.0	...	...
	440	0.60–1.20	16.0–18.0	...	Mo 0.75 max
Chromium base nonquench-hardening ferritic	430	0.12 max	14.0–18.0	...	...
	446	0.35 max	23.0–27.0	...	N 0.25 max
Chromium-nickel base austenitic	301	0.09–0.20	16.0–18.0	6.0–8.0	...
	302	0.09–0.20	17.0–19.0	8.0–10.0	...
	304	0.04–0.08	18.0–20.0	8.0–11.0	...
	304L	0.03 max			...
	310	0.25 max	24.0–26.0	19.0–22.0	...
	316	0.04–0.10	16.0–18.0	10.0–14.0	Mo 1.75–2.50
	316L	0.03 max			
	321	0.08 max	17.0–19.0	8.0–11.0	Min Ti = 5 × C
	347A	0.08 max	17.0–19.0	9.0–12.0	Min (Cb + Ta) = 8 × C

lography of stainless steels and stainless-steel weldments, it is necessary to have an understanding of the iron-chromium, iron-nickel, and iron-chromium-nickel constitution or phase diagrams. At the same time, it must be recognized that other elements will be present in all commercial steels and that these will alter the phase relations. The iron-chromium and iron-nickel diagrams are shown in juxtaposition in Fig. 1. Whereas increasing chromium restricts and eventually closes the gamma phase field, increasing nickel exerts just the opposite effect and widens the range of gamma stability. In either case, ferrite exists at low and high temperature. In the iron-chromium diagrams these two phases merge into one another when the chromium content is greater than about 13% chromium. Nevertheless, the microstructural appearances of these two forms of ferrite are readily distinguished in many alloys and it is common to speak of delta or high-temperature ferrite on one hand and alpha or low-temperature ferrite on the other.

Another feature of importance in the iron-chromium diagram is the occurrence of the sigma phase, a hard brittle, nonmagnetic phase based on the compound FeCr. Although the solubility of iron or chromium in sigma is relatively restricted, note that this phase may occur at quite low chromium concentrations. In fact, recent studies of commercial chromium ferrites place the lower limit at the order of 13% chromium at 900° F[4].

The most important additional element in the straight chromium steels is carbon, and the resulting constitution after rapid cooling from temperatures of maximum gamma is shown in Fig. 2. Carbon promotes the formation of austenite, and consequently opposes the tendency of chromium to close off the gamma field. It is to be noted, however, that a fully austenitic condition at heat treating temperature can be achieved only when the chromium content is less than about 20%. Consequently alloys containing more than this amount of chromium can never be heat treated to a fully martensitic structure. The solid line within the figure encompasses the compositions of commercial chromium stainless steels, with the two towers corresponding to high

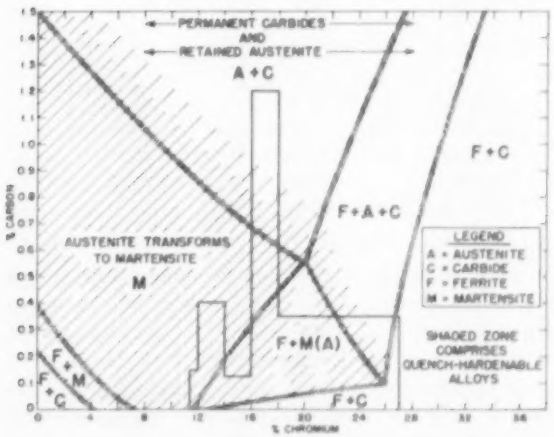

Fig. 2 Iron corner of Fe-Cr-C system after rapid cooling from temperatures of maximum austenite formation. Aborn[1]

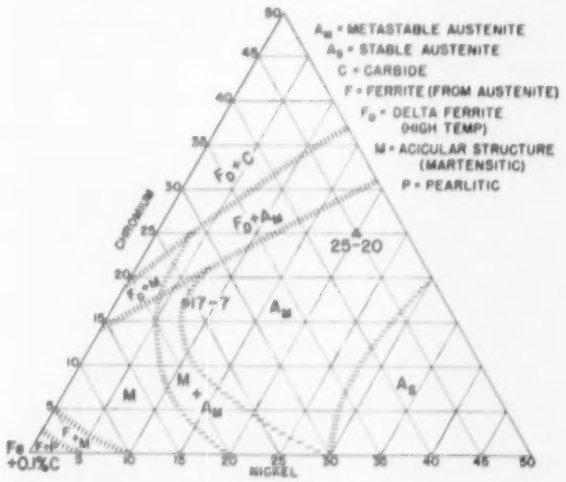

Fig. 3 Iron corner of Fe-Cr-Ni system (0.1% C) after rapid cooling from temperatures of maximum austenite formation. ASM Handbook[2]

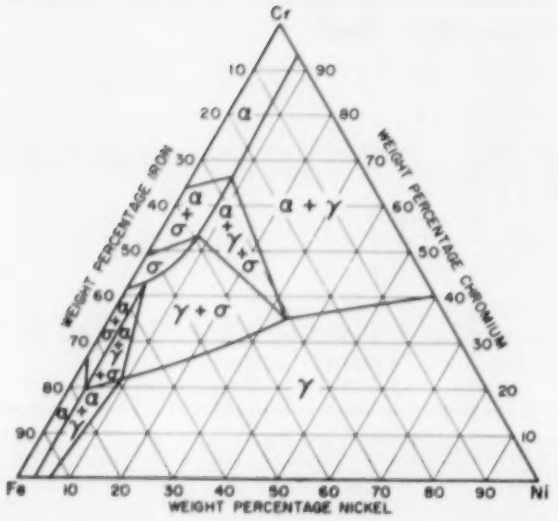

Fig. 4 Equilibrium of Fe-Cr-Ni alloys at 650° C (1200° F). ASM Handbook[3]

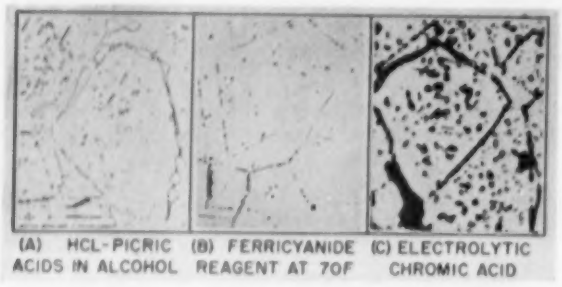

Fig. 5 Microstructure of 18 Cr–8 Ni-Mo steel containing austenite, sigma and carbide etched with different reagents. Dulis and Smith.[5] X 1000

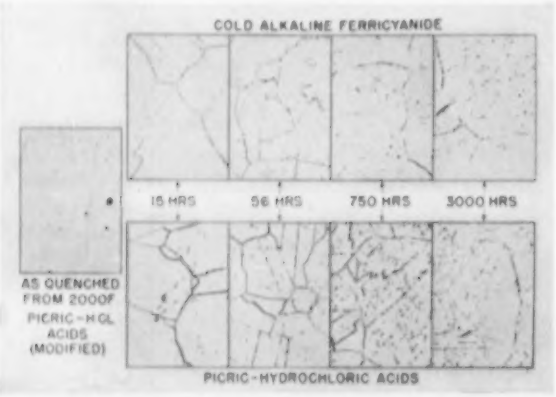

Fig. 6 Sigma and carbide formation in 18 Cr–8 Ni-Mo steel at 1500° F. Dulis and Smith.[5] X 1000

carbon types 420 and 440. The different phases which may be present in these steels are as follows: delta ferrite, alpha ferrite, austenite, carbide and sigma. Typical structures and microstructural differentiation of the phases will be illustrated below.

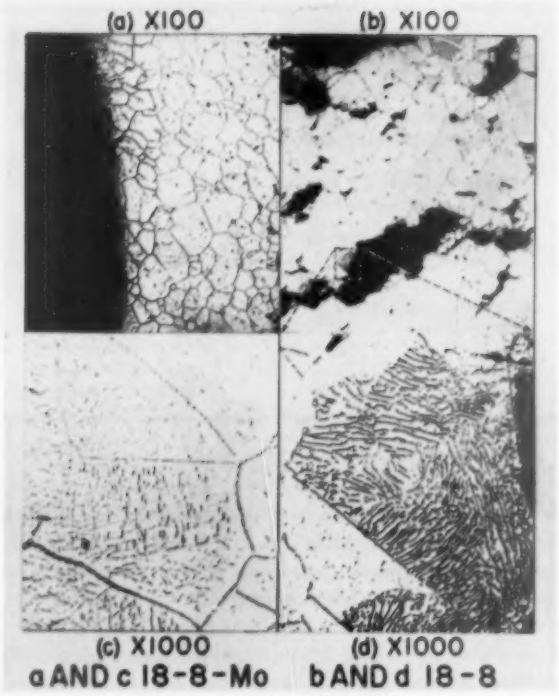

Fig. 7 Nitrogen pickup during creep rupture test at 1500° F. Smith, *et al.*[6]

Table 2—Classification of Etchants for Austenitic Stainless Steels. Dulis and Smith[5]

Acid reagents	HCl-picric acids in alcohol Aqua regia Mixed acids in glycerol
Alkaline ferricyanide reagents	Ferricyanide solution (used cold) Ferricyanide solution (used hot)
Electrolytic etchants	Chromic acid Sodium cyanide Oxalic acid

Table 3—Action of Etchants on Microconstituents of Austenitic Stainless Steels. Dulis and Smith[5]

	Acid reagents	*Alkaline ferricyanide (cold) (Murakami's)*	*Electrolytic etchants*
Austenite	Attacked	Unaffected	Slight attack
Sigma	Relief	Unaffected	Attacked
Carbide	Relief	Attacked	Attacked
Ferrite	Relief	Unaffected	Relief

* Exceptions described in the reference.

The constitution of the iron-chromium-nickel alloys after rapid cooling from temperatures of maximum austenite formation (1900–2000° F) is shown in Fig. 3. It is evident in this ternary section that the range of compositions in which austenite is stable at room temperature is quite restricted, and that the commercial 18Cr – 8Ni and 25Cr – 20Ni grades of austenitic stainless steels lie within the field of metastable austenite, whereas the 17Cr – 7Ni steel is at the border line of this

phase field. Metastable austenite may exist indefinitely unless the steel is plastically worked or cooled to subatmospheric temperatures.

The final section that we shall consider, Fig. 4, shows the phase relations at 650° C (1200° F) under equilibrium conditions, a state toward which these materials will tend when heated in this range as during welding or during service at elevated temperatures. The phases here encountered are, with one exception which will be mentioned, the same as those encountered in the straight chromium grades, but the predominant phase in commercial steels is now austenite rather than ferrite.

Microstructural Differentiation

Before attempting differentiation by microscopic means of the several phases present in the stainless steels, it is vital to insure that proper polishing procedures have been employed, so that the surface to be examined is free of so-called disturbed metal. Otherwise false structures will be observed. This is especially true of the austenitic steels and may necessitate the use of electrolytic polishing before the true structure can be developed.

Austenitic Steels

Turning now to the differentiation of the microconstituents, let us consider first the austenitic steels. The various etchants which are widely used for austenitic stainless steels fall into three broad categories as listed in Table 2. The actions of these etchants on the various phases that may occur are summarized in Table 3. One of the most useful reagents which reveals all the phases present is the alcoholic solution of picric and hydrochloric acids. It may be necessary to increase the amount of hydrochloric acid when etching certain steels. The ferricyanide and electrolytic reagents, on the other hand, are selective in their attack. The former reagent actually acts by staining, but the different colors produced are not reliable criteria for identification. Figure 5 illustrates the effects of etching the same sample in three different etchants for the purpose of differentiating the different phases. This sample of 18Cr – 8Ni-Mo steel had been in creep test for 3000 hr at 1500° F. The massive phase not stained by ferricyanide but attacked by the electrolytic etch is "sigma" phase (now known to be a mixture of sigma and chi or chi alone, which has properties similar to sigma but a different crystal structure, and occurs in grades containing molybdenum). Ferrite, if it had been present, would have appeared in relief in the first etch and been unstained or unattacked by the latter two reagents. As illustrated, the different phases cannot be differentiated by means of any one etchant, but rather, it is necessary to use several in succession, as for example in the procedure recommended in Table 4.

Table 4—Proposed Method of Etching Identification of Microconstituents in Austenitic Stainless Steels. Dulis and Smith[5]

1. Remove disturbed metal by repeated polishing and etching (acid reagent)
2. Etch in picric and hydrochloric acids in alcohol
3. Repolish and etch in cold alkaline ferricyanide
4. Repolish and etch in chromic acid, electrolytically

In further illustration of the effectiveness of such an etching procedure, Fig. 6 will be of interest. This shows the relatively rapid precipitation of carbide and the much slower precipitation of "sigma" (chi) phase in 18Cr – Ni-Mo steel at 1500° F. Only the carbide phase is revealed by the ferricyanide reagent; both carbide and chi are shown by the acid reagent.

When delta or high temperature ferrite is present as a minor constituent in austenitic steels, it is generally present as stringers. On heating at elevated temperatures, delta ferrite transforms to sigma, and the process of transformation may result in a constituent of multiphase appearance which presumably comprises sigma, ferrite and austenite and possibly carbide. Upon completion of the transformation, the sigma that has developed has much similarity to delta ferrite in the acid etchants.

It is often helpful to supplement microscopic examination by measurement of other properties. Thus, since delta ferrite is ferromagnetic whereas austenite, carbide and sigma are not, permeability measurements may be used to confirm the results of metallographic examination. Another example of the helpfulness of other tools is the use of microhardness indents to reveal differences in hardness; in one example, a particle of sigma was found to have a hardness of approximately 750 dph whereas hardness of the austenitic matrix was 150 dph.

Sigma phase is stable only at temperatures below some 1600–1700° F, and if a sample of austenitic steel containing sigma is heated above this range, it is to be expected that the sigma will redissolve in the austenite. Curiously, however, it sometimes does so by first forming delta ferrite, which in turn dissolves in austenite. This sequence of events has been confirmed by magnetic permeability measurements.

The stainless steels have a strong affinity for nitrogen and may absorb this element from the atmosphere during prolonged exposure at elevated temperatures, Fig. 7. The nitrides that form may exhibit either a Widmanstätten or a lamellar form.

As a last example of macrostructures of austenitic steels, Fig. 8 shows the effect of cold working and of the reheating of such material, in contrast to unworked metal. Not only do the usual slip bands appear on working, but in a number of the leaner austenitic steels, transformation to ferrite (martensite) also occurs. On heating in the so-called sensitization range, wherein carbide precipitates, this precipitation occurs along the slip bands in cold-worked metal whereas it occurs almost exclusively at the grain boundaries in unworked metal.

Martensitic and Ferritic Steels

The constituents to be differentiated in ferritic or martensitic stainless steels are delta ferrite, alpha ferrite, martensite, carbide, sigma and retained austenite.

Annealed and quenched microstructures of the chro-

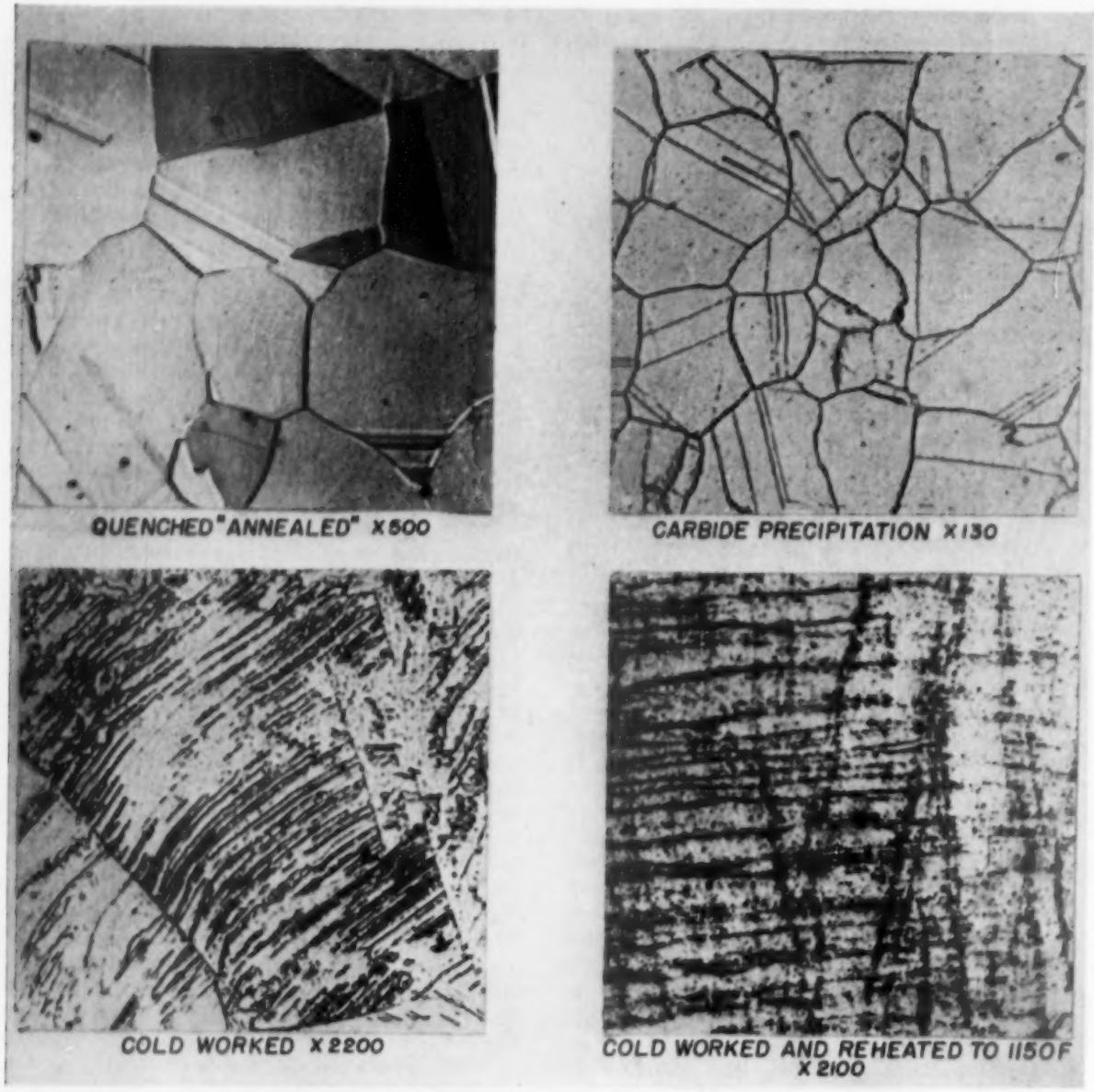

Fig. 8 Microstructure of 18 Cr–8 Ni steel after various treatments. Aborn and Bain[9]

Fig. 9 Annealed and quenched and tempered microstructures of 12 Cr stainless steel. Aborn[12]

mium stainless steels reveal quite conventional-appearing microstructures, and as with the austenitic steels, it is the appearance of the sigma phase after prolonged heating at elevated temperatures that may cause difficulty because of its similarity to carbide under many etchants. However, sigma may be readily differentiated in these steels by contrasting the appearance after etching in glyceregia with that after etching in an alcoholic solution of picric and hydrochloric acids.

The characteristic appearance of the microstructures of several commercial steels are shown in the following several figures as etched in picric and hydrochloric acids in alcohol. Figure 9 shows the annealed and quenched-and-tempered microstructures of Type 410 steel (12 Cr); Fig. 10 shows the annealed and quenched microstruc-

Fig. 10 Microstructures of 17 Cr stainless steel. Bain[10]

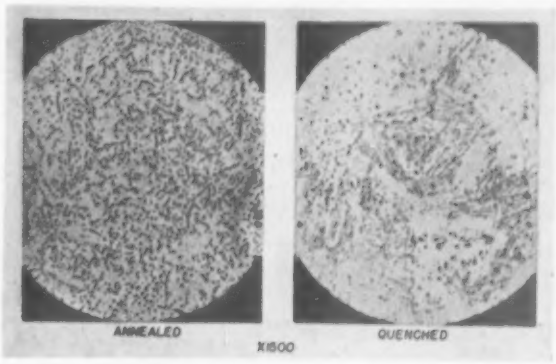

Fig. 11 Annealed and quenched microstructures of stainless cutlery steel. Bain[10]

Fig. 12 Macrograph of two-pass submerged-arc austenitic weld, with manual root passes in 1.5-in. plate. Miller and Houston[7]

tures of Type 430 steel (17 Cr), in which delta ferrite will be noted; and Fig. 11 shows the microstructures of cutlery stainless steel (perhaps 13Cr – 0.4C) in the annealed and quenched conditions.

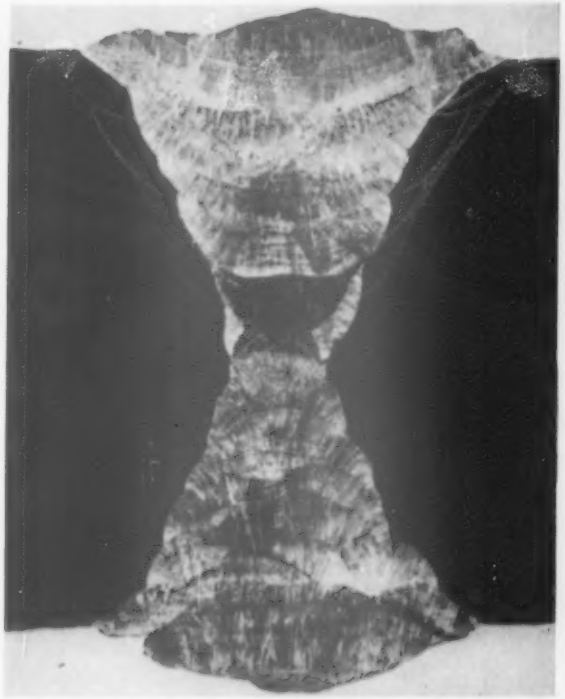

Fig. 13 Macrograph of manual arc austenitic weld in 1.5-in. plate. Miller and Houston[7]

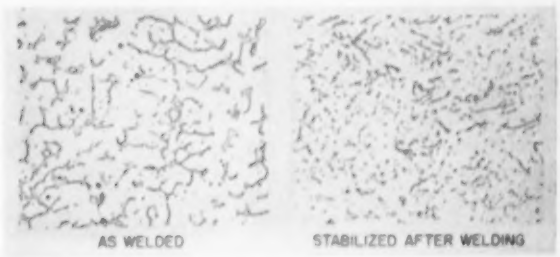

Fig. 14 Microstructures of 18 Cr–8 Ni-Cb weld metal. Vilella.[5] X 500

Weldments

Let us now turn to the metallography of stainless-steel weldments. Here we are concerned not only with welds between stainless steels, but also with welds between stainless and nonstainless steel, as well as with welds between nonstainless steels, for stainless-steel electrodes may be used even in the last case cited, as for example in welding armor plate.

The macro-appearance of a weldment is often helpful in defining the regions of interest, Fig. 12, e.g., heat-affected zone, fusion line or weld metal, and the path of fracture with reference to the structure. Figure 13 is another example of a macrograph of a weldment, in this case a multipass weld. The specimens for these photomacrographs were prepared by first providing the entire section with a polish suitable for microexamination; this is not nearly so difficult as it may seem. Etching was then accomplished electrolytically in a 10% solution of chromic acid.

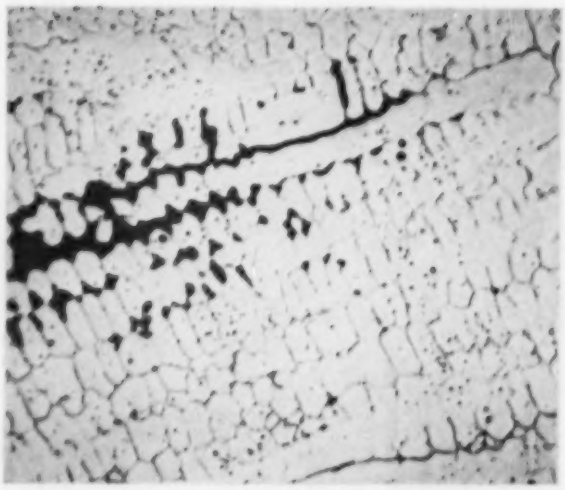

Fig. 15 Dendritic voids and trapped slag in 18 Cr–8 Ni-Cb weld metal. Vilella[5] X 100

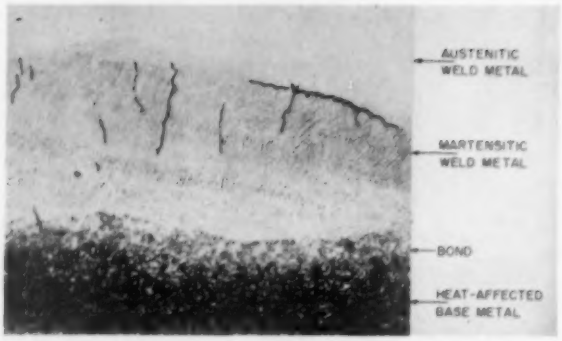

Fig. 16 Martensite in heat-affected zone of 25 Cr–20 Ni stainless bead weld on 2.25 Cr–1 Mo steel. Longitudinal section. Doty.[11] X 100

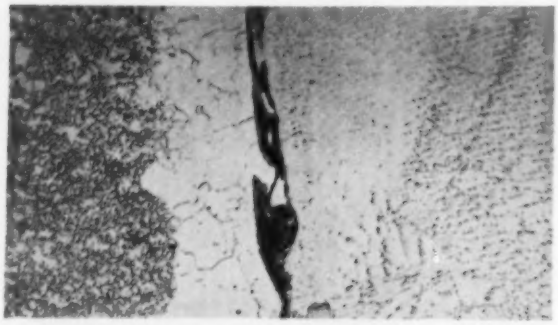

Fig. 17 Carbon migration in ferritic-austenitic joint. Mochel[13]

In interpreting the microstructures of weld metal it is well to keep in mind that welding is analogous to casting. Hence microstructures may show all the characteristics of a casting; for example, the dendritic structure in the left half of Figure 14. In this case, the microstructure consists of dendritic ferrite, which is often intentionally present in austenitic weld metal because it minimizes weld cracking, along with small carbides in an austenitic matrix. The second half of the illustration illustrates the breaking up of the dendritic structure as a result of reheating for 2 hr at 1600° F. A similar breakup would tend to result in the passes of a multipass weldment as a result of the heating during subsequent passes.

The various kinds of defects that are common to a casting may be seen in weld metal, as for example the slag inclusions or dendritic shrinkage in the cored austenite of Fig. 15.

When ferritic steels are welded with austenitic electrodes, a zone of martensite often occurs, Fig. 16, either in the base metal as a result of rapid cooling or in the dilution zone as a result of alloying combined with rapid cooling. Figure 16 provides an example of such microstructure. Another possibility that may be expected in ferritic-austenitic weldments is the migration of carbon to the interface and into the austenite, Fig. 17. This phenomenon may occur during prolonged service at elevated temperatures.

Summary

Starting with a properly polished specimen, the differentiation of the several microconstituents of stainless steels can generally be accomplished with certainty. It is usually necessary, however, to use several etchants in turn, since there is no single etchant that will simultaneously provide an effective differentiation of all microconstituents. In some cases it is helpful to employ other metallographic tools such as microhardness or X-ray diffraction tests.

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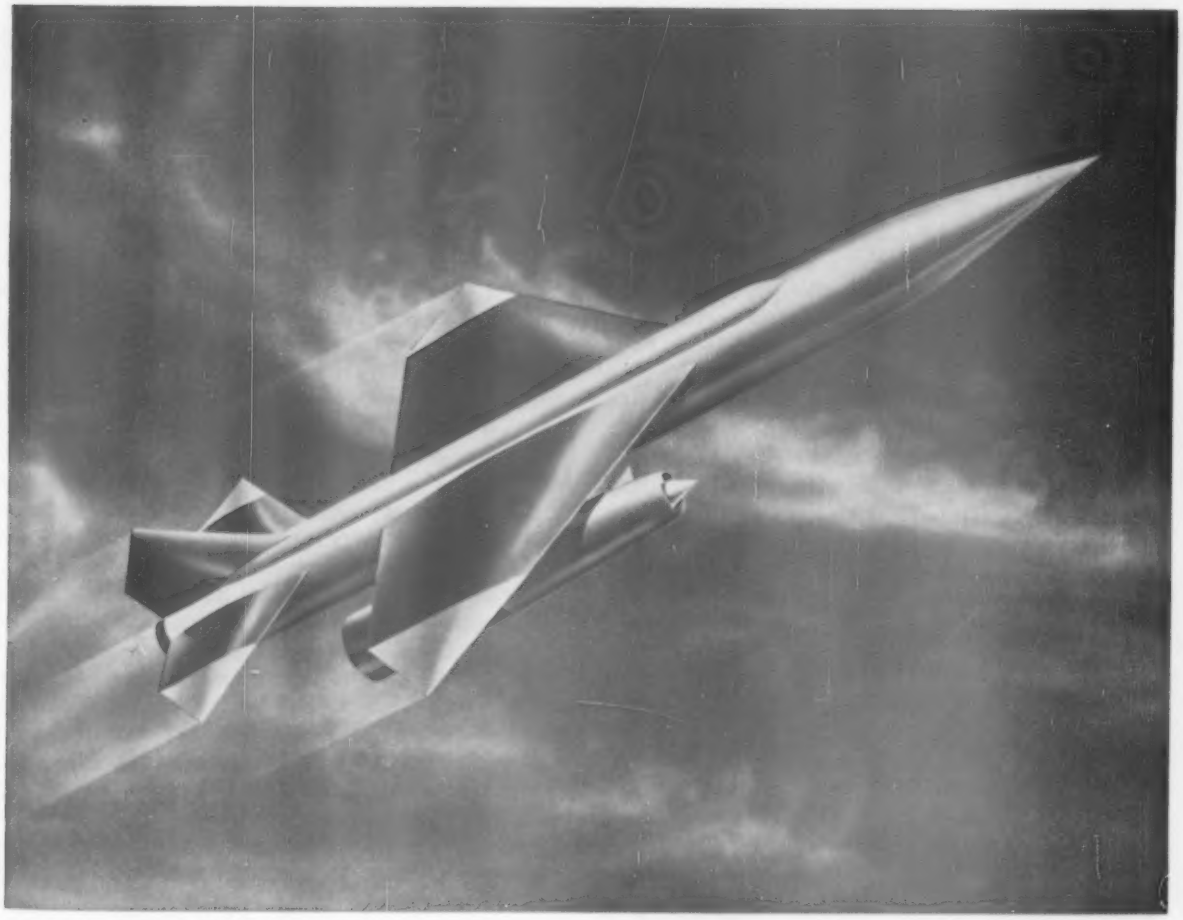

Artist's conception of Bomarc missile

RESISTANCE WELDING DUCTILE JOINTS IN COMMERCIALLY PURE TITANIUM

BY R. WICKHAM

Author indicates that high-ductility resistance welds in commercially-pure titanium can be produced provided all welding variables are closely controlled

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Presented at AWS 1955 National Fall Meeting held in Philadelphia, Pa., Oct. 17–21.

Introduction

The fabrication of modern day aircraft and their power plants requires that the resistance-welded joints that are used extensively in their construction be capable of withstanding the high dynamic loads that are applied in service. Spot and seam welds must possess uniform strength and maximum ductility to provide the reliability necessary to justify their use as means of making structural joints. The ability to produce high strength and especially ductile welds in commercially pure titanium and weldable titanium alloys has been a challenge to the welding engineer. Using resistance welding experience gained by welding the high-temperature alloys, stainless steels, aluminum and alloy steels along

with the precise heating, cooling, and pressure cycles of the modern electronically controlled welding machine, welding engineers at Marquardt Aircraft Co. have developed extremely ductile, high-strength resistance-welded joints in titanium.

The principal problems that had to be overcome were: embrittlement due to contamination of the weld nugget by the air, limiting the penetration of the fused zone of the weld, control of grain size and orientation, keeping the resultant weld shear strength at a reasonable and uniform level, controlling the size of the heat-affected zone of the weld, and determining the effect of the many welding machine variables on the resultant properties of the weld.

Standard procedures for welding nonhardenable stainless steels and high-temperature alloys were not satisfactory for welding nonhardenable titanium. Precise heat control and a definite heating and cooling cycle became the primary objectives as they are in fusion welding titanium where maximum ductility is desired. The use of controls on the welder control panel normally used for hardenable steels was investigated to obtain the optimum heating cycles desired.

Welding Conditions

The material used in all testing was commercially pure titanium, MST Grade III. The material was 0.040 in. thick, had an average ultimate tensile strength of 90,000 psi, a yield strength of 80,000 psi, and an elongation to fracture of 20% measured over a 2-in. gage length. The sheet was received in the annealed and pickled condition and could be formed 180 deg over a $2T$ bend radius (where T = material thickness) without fracture. All test joints were made on a three-phase 75-kva press-type frequency converter welder. A control panel designed specifically for this welder was used to control the welding variables. The electrodes, top and bottom, were RWMA Class II machined to have a 3-in. radius dome. The electrodes were fluted and were cooled with refrigerated water at a temperature of 60° F at a flow rate of 2 gpm. Figure 1 is a picture of the machine used in this study.

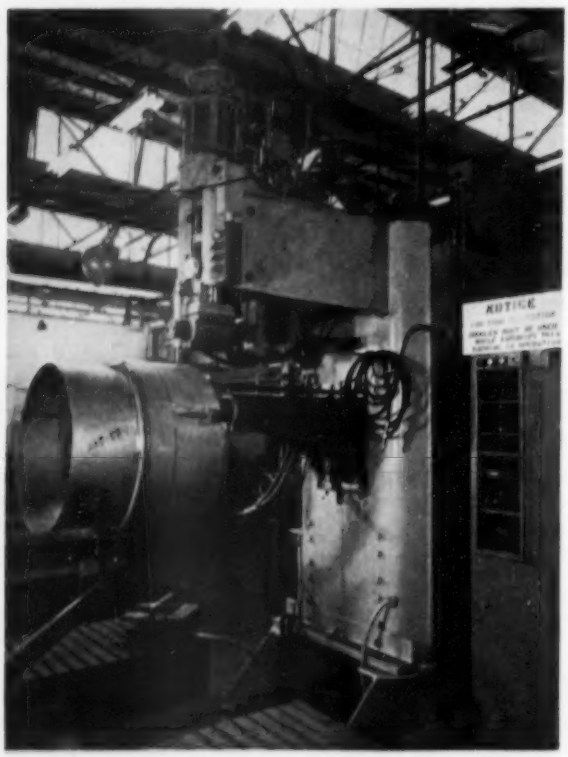

Fig. 1 75-kva spot welder

The as-received material was surface cleaned with a solvent preparatory to welding. No attempt was made to remove the surface oxide that is present on the mill pickled sheet. The sheet-to-sheet surface contact resistance was measured using a contact resistance device embodying a micro-ohmmeter. It was determined that the contact resistance between the sheets after a solvent clean was a fairly consistent 175 microhms, entirely suitable for the resistance welding operation.

The test specimens welded to determine the effects of the welding variables on tension shear strength, cross tension strength and ductility were dimensioned in accordance with recommended AWS standards. The test specimens were welded in suitable aligning fixtures to prevent bending or twisting loads from entering the joint during testing. All tests were performed in a 5000-lb hydraulically actuated testing machine.

Each welding schedule investigated produced five specimens for the tension shear test, five more for the cross tension test, and an additional two samples for bend testing as well as metallographic specimens. The final welding schedules were used to produce at least 20 samples for each test to result in a reliable average value for each major phase of the investigation. All specimens were pulled to failure at a constant loading rate. All bends were made across the weld over a $2T$ radius (where T is the total material thickness of the joint) in a brake.

Metallographic specimens to determine weld diameter, penetration, grain size, and orientation, extent of heat-affected zone, and presence or absence of defects were prepared using standard metallographic techniques for polishing titanium. The specimens were etched in a solution composed of 12% nitric acid, 1% hydrofluoric acid, and balance water.

Determination of Welding Schedules

Machine settings were determined using the standard control variables of welding current, pressure and welding time that would produce an acceptable weld in a material with the particular characteristics of titanium: medium high yield strength, low thermal conductivity, surface resistance in the pickled condition of approximately 175 microhms and a tendency to embrittle by absorbing gases from the atmosphere when in the molten state. A discussion of the machine settings used in the earlier schedules will serve to define better the problems involved in making acceptable welds in titanium sheet.

The least critical of the machine variables seemed to be electrode size, tip radii and electrode pressure. The electrode materials were RWMA Class 2. This material has an electrical resistance that results in an optimum current density through the joint to be made. Using Class 1 electrodes resulted in surface burning of the titanium and deformation of the electrode face. Using Class 3 electrodes for titanium results in lack of sufficient penetration to make a strong weld. This is due to the high current density in the electrodes and the tendency to bleed current through the part too slowly to make a satisfactory weld.

The tip radii and electrode size control the size of the nugget, the outside surface indentation at the weld, and the flow of current through the sheet to be welded. It was found that tip radii over a fairly wide range could be used satisfactorily with titanium. In this case, the titanium with its low thermal conductivity behaves like steel. The heat that is built up at the spot to cause fusion is localized by the low thermal conductivity. Therefore, the size of the electrode contact with the sheet and the resultant current density through the sheet is not critical. Aluminum, on the other hand, has a high thermal conductivity that spreads the welding heat rapidly and requires critical control of the tip radii to get an acceptable weld. The combination of electrode size and tip radii used in this investigation resulted in a weld nugget diameter that was a standard 4–5 times the single sheet thickness.

The welding pressure used in making a spot weld must be carefully considered when making a machine schedule as it is an important variable that contributes to the amount of heat put into the weld. In addition, pressure has a sizable effect on the outside surface indentation and on the microstructure of the resultant weld. It was found that a variation in the pressure over a considerable range did not adversely affect the resultant weld in titanium. This is due in part to the high yield strength of the material that prevents surface deformation at the electrode contact points and in part to the high electrical resistance of both the surface of the titanium and the base metal itself. This effect is similar to that in steel. The actual pressures used in welding commercially pure titanium are the same as would be used in welding 300 series stainless steel at equivalent thicknesses.

The combination of weld current and time proved to be the critical variables in resistance welding this material. As in fusion welding, the amount of heat in the weld area and the manner in which it is introduced and distributed are the keys to ductile, high-strength joints. The original current and weld time were selected on the basis that would result in a minimum heating of the sheet for the shortest time to result in a sufficiently fused weld.

The selection of welding current and time was based on at least two characteristics of titanium that tend to reduce the ductility of a resistance weld. The two characteristics are absorption of interstitial alloying elements from the atmosphere and rapid rate of grain growth at the temperatures that are reached in the weld and weld zone. To reduce these two mechanisms to a minimum and at the same time obtain a sufficient amount of fusion and penetration in the weld, the welding current and time were varied to put a minimum amount of heat into the weld for the shortest amount of time. After several tests, it was determined that the short time was more critical than the level of heat in preventing gas absorption and grain growth. Therefore, a heat value near the top side of the experimental range explored was used and the welding time cut to a minimum. At the same time, consideration had to be taken of nugget penetration and the current kept at a low enough value to prevent excess penetration. In titanium, unlike many other materials, too much penetration rather than too little is the primary problem. Penetrations in excess of the limiting 80% of the MIL specifications are easy to obtain. Once the penetration factors were controlled, however, variations in heating history did not seem to have a great effect on penetration.

The welding time is controlled in modern three-phase frequency converter resistance welding machines by a combination of weld cycles and pulse cycles. Weld cycles are a direct measure of the total amount of time that heat is being created in the weld area. Each weld cycle represents $^1/_{10}$ of a second. Pulse cycles are a measure of the effective volume of current that is introduced into the weld in each weld cycle and the rate of introduction of the welding current in each weld cycle. Too low a number of pulse cycles results in such a fast introduction of current into the outside surfaces of the sheets from the electrode tips that the current is diffused through the outer surfaces of the sheet resulting in excessive surface embrittlement and lack of fusion. Too high a number of pulse cycles even at a low number of weld cycles introduces too much heat into the titanium and results in embrittlement and even burning of the metal. It was found that the optimum setting for titanium to result in a minimum heating time and low current input was two pulse cycles and one weld cycle.

The welding time and rate of heat input (weld cycles and pulse cycles) used in welding titanium are similar to those used in welding aluminum. On the other hand, the current and pressure found to be best for welding titanium are very similar to those used for stainless steel.

The final set of machine settings used are shown in Table 1.

Table 1—Initial Machine Settings

Welding current, amp	34,600
Pulse, cycles	2
Weld, cycles	1
Electrode force, lb	2,500
Squeeze time, cycles	25
Hold time, cycles	60

A series of spot runs using this welding schedule on two pieces of 0.040-in. thick material possessed the average physical properties given in Table 2. All ten-

Table 2—Test Results from Initial Machine Settings

Tension shear strength, lb	2540
Cross tension strength, lb	575
Weld penetration, %	80
Weld nugget diameter, in.	0.200
Sheet separation, in.	0.007
Bend angle across weld over 2*T* radius, deg	130

Table 3—Machine Settings Utilizing Preheat

Welding current, amp	27,300
Pulse, cycles	2
Weld, cycles	1
Electrode force, lb	2,500
Squeeze time, cycles	25
Hold time, cycles	60
Preheat current, %	40
Preheat time, cycles	1

Table 4—Test Results Utilizing Preheat

Tension shear strength, lb	2400
Cross tension strength, lb	575
Weld penetration, %	80
Weld nugget diameter, in.	0.200
Sheet separation, in.	0.004
Bend angle across weld over 2*T* radius, deg	145

sile shear specimens failed by pulling buttons from one of the jointed sheets. The appearance of the fractured joint indicated that the optimum in the way of a ductile joint had not been obtained with the machine schedule used. While the weld did pull a button rather than fracturing across the pull specimen, there was no evidence of ductile metal flow in the nugget. The sides of the pulled button were perpendicular to the sheet surface. No local flow of the nugget had taken place. Also, the bend angle across the weld was not satisfactory. The base metal and fusion welds in the same material are capable of bending a minimum of 180 deg over a 2*T* radius. The goal of this investigation was to obtain the same ductility in resistance welds or have an excellent reason or reasons for not being able to obtain this degree of ductility.

Use of Preheat and Postheat

An intense investigation was carried out to determine means of further lowering the amount of heat in the weld. Using a minimum of current and weld time to obtain sufficient fusion (described in the foregoing paragraphs) still resulted in enough interstitial alloying of the metal from atmospheric gases to embrittle the weld beyond acceptable limits. In addition, the settings used resulted in too high a shear strength, too low a cross tension strength and too much sheet separation. Yet it should be understood that the machine schedule described above was the best one that could be developed using the standard machine variables.

Preheat

Borrowing from recent experiences fusion welding titanium, the use of a preheat was attempted to determine whether, through its use, the welding heat could be reduced. The use of preheat slowly heats the metal at some low current input to an elevated temperature considerably below the fusion temperature. The elevated temperature of the material at the time of welding could conceivably allow the actual weld current input to be reduced. Using preheat in this manner is rather unorthodox as it is usually used only on martensitic hardening steels. Determining the amount and duration of preheat and the corresponding reduction in welding current required extensive testing.

The preheating was done at a low current input and for a short time. It was found that when using preheat to reduce the weld current and time, the control of the current and time became very critical. However, with a good balance of preheat and weld heat, satisfactory nuggets could be produced. After considerable experimenting, the machine schedule in Table 3 was determined for two pieces of 0.040-in. thick material. It can be seen that with the use of preheat, the weld current value can be considerably reduced from that necessary when preheat is not used.

Using this machine schedule, the physical properties given in Table 4 were obtained in the sets of test specimens. The use of preheat helped to increase the bend ductility of the joint, reduce the sheet separation to within acceptable limits and reduce the excessive shear strength. As in the first series of tests, the shear specimens pulled a button from one of the joined sheets. The appearance of the fractured nugget, while an improvement over previous efforts, still did not attain the optimum in ductility.

Postheat

Further efforts were made to reduce the weld current. In conjunction with these efforts, the use of postheat was attempted to see if the combination of postheat with preheat would allow a further reduction in weld current and whether the use of postheat would partially anneal or stress relieve the cooling weld nugget and surrounding heat-affected zone. Postheat is applied immediately after the weld current and serves to slow and control the rate of cooling.

It was found that the use of postheat made all the machine settings more critical, but still within the range of production feasibility. It was determined that with the use of preheat and postheat and the accompanying reduction in weld current, changes in weld current of as little as $^1/_2$ of 1% could markedly affect the weld. It is, therefore, demanded that the electronically controlled welding machine be used when welding titanium, using

Table 5—Machine Settings Utilizing Pre- and Postheat

Welding current, amp	25,400
Pulse, cycles	2
Weld, cycles	1
Electrode force, lb	2,500
Squeeze time, cycles	25
Hold time, cycles	60
Preheat current, %	40
Preheat, cycles	1
Postheat current, %	20
Postheat, cycles	2

Table 6—Test Results Utilizing Pre- and Postheat

Tension shear strength, lb	2125
Cross tension strength, lb	720
Weld penetration, %	80
Weld nugget diameter, in.	0.200
Sheet separation, in.	0.002
Bend angle across weld over 2T radius, deg	180 without fracture

the techniques reported on herein. It is also important that the power supply to the welding machines be uniform.

After considerable testing, an optimum set of machine settings were determined using preheat, postheat and low current. The values are given in Table 5. Using this machine schedule, the physical properties shown in Table 6 were determined for the test specimens. All shear specimens pulled a button from one of the welded sheets, but unlike the other series of tests, there was definite flow of the metal. Figure 2 shows a nugget with no flow and, next to it, a nugget which does show evidence of metal flow.

Comparing the weld properties obtained using preheat, postheat and low current with those of previous tests not using this degree of welding machine scheduling, it can be seen that the weld properties have been optimized in all aspects. The high shear strength has been decidedly lowered; the cross tension strength is now an acceptable value; weld penetration has not changed and is satisfactory; sheet separation has markedly improved; and the requirement for satisfactory ductility which prompted this investigation has been realized (see Fig. 3). It is felt that welds with these properties provide the engineer greater assurance in the consideration of dynamic loading.

Structure of Weld and Weld Zone

Figure 4 is a picture of a cross section of the weld and weld area. The macrostructure of weld made in all three series of tests were identical in appearance. The actual weld nugget consists of large columnar grains extending outward from the sheet interface. At the edge of the fusion zone are more or less equiaxed transition grains. Surrounding the weld nugget is a well-defined heat-affected zone which penetrates at least 95% of the sheet thickness.

Rockwell A hardness readings taken in the base metal, heat-affected zone and weld nugget resulted in hardness values on the Rockwell A scale of 60, 58, and 62, respectively. These values are a normal gradient for this type of weld.

The microstructure of the weld and weld area consists of a heat-affected zone of small acicular alpha and a nugget of basket weave alpha with an ASTM grain size of 2. This structure is considered normal for this material. No retained beta was observed.

Conclusions

1. High ductility welds in commercially pure titanium can be produced provided all welding variables are closely controlled.

2. The use of preheat and postheat enables the welding current to be reduced to a level that results in an optimum resistance weld with excellent base metal ductility and uniform strength.

3. Normal levels of welding current necessary to obtain sufficient fusion in the weld, results in some contamination and embrittlement of the weld.

4. The use of preheat had the greatest effect on reducing the necessary weld current level.

5. The use of postheat partially annealed the weld, reducing shear strength, residual stresses and increasing bend ductility.

6. The effect of minimum weld current time is more important in controlling the weld quality than is weld current level.

7. The surface resistance of mill pickled titanium sheet is satisfactory for resistance welding without further treatment, other than solvent cleaning.

The use of this welding technique has been successfully used on production parts. While the technique does require a very close control of the welding variables, particularly current, the advantages gained far outweigh the disadvantages. While no actual fatigue tests have been performed on welds made using preheat, postheat and low current, the excellent ductility and strength of these joints should assure satisfactory fatigue strength. The use of preheat and postheat in welding titanium alloys has not been attempted to any extent at this time. However, it is felt that the weldable alloys will respond to this technique in a manner similar to the commercially pure material.

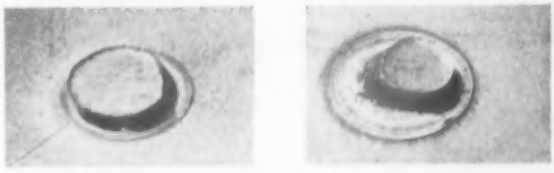

Fig. 2 Metal flow in titanium weld nuggets

Fig. 3 Ductile spot weld bend specimens

Fig. 4 Titanium weld nugget

First metallizing accomplished by hand feeding filler rod into a rocket jet

METAL SPRAYING WITH ROCKETS

New process, as yet untried in industry, claimed to offer some advantages over presently available air-blast guns

BY J. W. BUFFINGTON AND J. A. BROWNING

ABSTRACT. Small rockets have been successfully adapted for metallizing. The high-temperature, high-velocity jet produced by the combustion process in a rocket melts and atomizes a metal rod into a fine spray of molten particles. This spray is projected at high velocity and is deposited on the prepared surface to form a coating. The chief advantage of this technique of metallizing is derived from the rocket metallizer's ability to control the average particle size over the wide range of 20μ to over 200μ. The particle size of sprayed steel was found to decrease with increasing oxygen-to-propane ratio and with increasing total input of oxygen and propane. It was also found that the bond strength of a sprayed steel coating is increased by decreasing the average size of the particles sprayed and by using smaller oxygen-to-fuel ratios.

The Rocket Metallizer

During the past year a new method of metallizing has been developed using the principles of rocket combustion. The high-temperature, high-velocity jet exiting through the rocket nozzle is used to melt and atomize a metal wire which is fed through the rocket throat. The atomized metal is sprayed onto a previously prepared surface (see Fig. 1).

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With this new type metallizing gun, the procedure remains essentially unchanged from that used with the present commercial metallizing methods. The major difference between the two types of units is in the method of heating and atomizing the wire. The air-blast gun utilizes an open oxy-fuel flame to heat the wire, and a stream of compressed air atomizes the molten metal. The use of rocket energy to perform these functions obviates the use of the compressed air system. The rocket metallizer is not suited for the use of acetylene which is unsafe when used at gage pressures over 15 psi. Propane and similar fuels are used. The method of cooling is different in each of the two cases. The rocket must be water-cooled.

Figure 2 is a schematic representation of the equipment necessary for trouble-free operation of the rocket metallizer. A photograph shows this device in action in Fig. 3. This is the apparatus used in the investigations to be described later.

Oxygen and propane are led through pressure regulators at 100 psig and 115 psig respectively. These gases are forced through injectors into the combustion chamber of the rocket. The combustion temperature

is about 5400° F. The exit gases composing the jet travel at a velocity of nearly a mile per second. The temperature of this jet is over 5000° F as determined by the fact that the flame melts molybdenum (melting point 4750° F). Shock diamonds are visible in the exiting gas stream. Thus, it is known that the jet velocity is sonic, or greater. Wire is fed into the rocket's throat at a constant speed by means of a thyratron-controlled d-c motor.

The critical part of the metallizing rocket is its throat (Fig. 4), which must have the correct cross-sectional area such that the wire can be heated to the desired temperature and still allow the gases to retain sufficient kinetic energy for adequate atomization. The length of the throat and the rod feed rate must be balanced so that atomization will take place beyond the throat exit. If the wire becomes molten within the rocket, the throat is apt to become plugged and the flame is extinguished. On the other hand, if the wire emerges too quickly, the atmosphere will cool the wire before atomization can occur. (Preliminary designs attempted to pass the wire through the entire combustion chamber prior to passing it into the throat. Although at times successful, the operation of this unit was critical. Too much heat passed into the wire. The alternate system of introducing the wire directly to the throat has proved very satisfactory, and allows a wide range of feed rates.)

For successful metallizing, the size of the rocket throat, the feed of the wire, the oxygen-to-fuel ratio, and the total gas input must be in proper balance. To obtain such a balance, any of these variables may be changed within limits. For high feed rates at constant combustion intensity a rocket would be used which had a long throat. These rockets are interchangeable in much the same fashion as welding tips. The variables other than the size of the rocket throat may be adjusted while the unit is in operation. An experienced operator can judge quite accurately the proper metallizing spray pattern.

With further development the rocket metallizer should be able to accomplish all tasks that are now done by the air-blast gun. Furthermore, it is expected that this new device will open up new fields of application. These will be due primarily to its ability to produce metal particles of much smaller diameter than is presently possible, and to control the average particle size over a considerable size range.

It is quite possible that the rocket metallizer will be able to simplify the process of protective spraying. At present, protective metallizing is generally followed by a fusing operation to close the pores in the applied coat. If the metal can be sprayed in sufficiently small particles, it might be possible to eliminate the subsequent fusing operation. Furthermore, in the rocket metallizer the carrier gases are hot rather than cold as in the air-blast guns. This inherently results in some fusing when the particles hit the surface being sprayed. It is believed that this intrinsic fusing coupled with the small particle size will render a simpler and more economic metallizing procedure for protective spraying.

The rocket metallizer has not been made, or run, on a commercial basis, but all indications predict that the installed cost should be considerably less than for present commercial installations. No air compressor is required, and the unit itself is simple to manufacture. The operating costs of this new device should be about equal to that of present methods. The rocket metallizer requires more oxygen and fuel per unit time. However, inexpensive propane is substituted for acetylene. The expense of operating an air compressor would not be incurred. The rocket metallizer can deposit more pounds of sprayed metal per hour than conventional methods. Thus, a considerable labor saving should be realized.

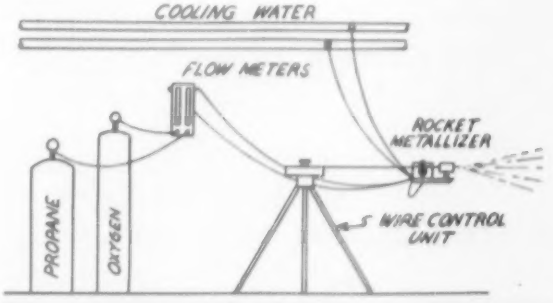

Fig. 2 The installation required for trouble-free operation of the rocket metallizer

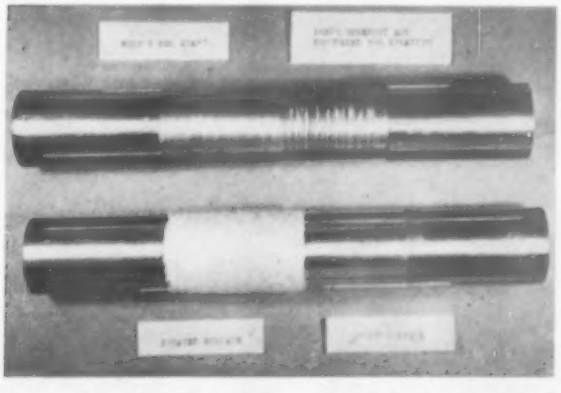

Fig. 1 Example of metallizing with brass over a steel shaft

Fig. 3 The rocket metallizer in action

Experimental Investigation

An investigation of particle size and bond strength has been made. Mild-steel welding rods were fed through the rocket metallizer, and the spray directed into a container of water. The particles were then collected and viewed through a biological microscope (Figs. 5 and 6). Particle size was determined against a calibrated scale within the microscope. The gas flow rates were found by use of rotameters.

The procedure followed in measuring the bond strength of the deposited metal coating was suggested by one of the leading metallizing companies in the industry. Three $^1/_2$-in. diameter holes were drilled in a number of steel plates. A cylindrical plug 4 in. in length was fitted into each of these holes and locked in place by means of a set-screw. The face of each piece to be coated was then roughened by grit blasting. Steel was sprayed to form a coating approximately $^1/_{32}$-in. thick. The force required to pull the plug away from the metallized coating was recorded.

Particle size was controlled by utilizing the results of the previous series of tests. All tests have been made at a constant wire feed rate of 3.7 fpm.

Figure 7 shows the average particle size of sprayed steel as a function of the total input of oxygen plus propane and of the oxygen-to-propane ratio. The curves indicate that the average particle size decreases with increasing total gas consumption for a constant oxygen-to-propane ratio. Also, for a constant input, the particle size decreases for increasing values of oxygen-to-fuel. The metal can not be sprayed if the total gas input is too low, for then there is not enough available energy to melt and atomize the wire at the chosen speed of 3.7 fpm. However, if the wire were fed at a slower rate, another curve could be plotted which would be lower on the total gas input axis. Similarly, the metal will not be sprayed if the total gas input with any given oxygen-to-fuel ratio becomes too great. In such a case, the wire becomes molten before it passes out of the rocket throat. This was found to plug the throat and to extinguish the flame. In case of too large a total gas input, equilibrium con-

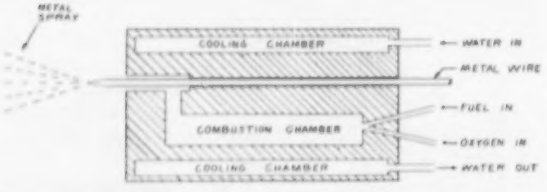

Fig. 4 Cross-sectional view of rocket metallizer

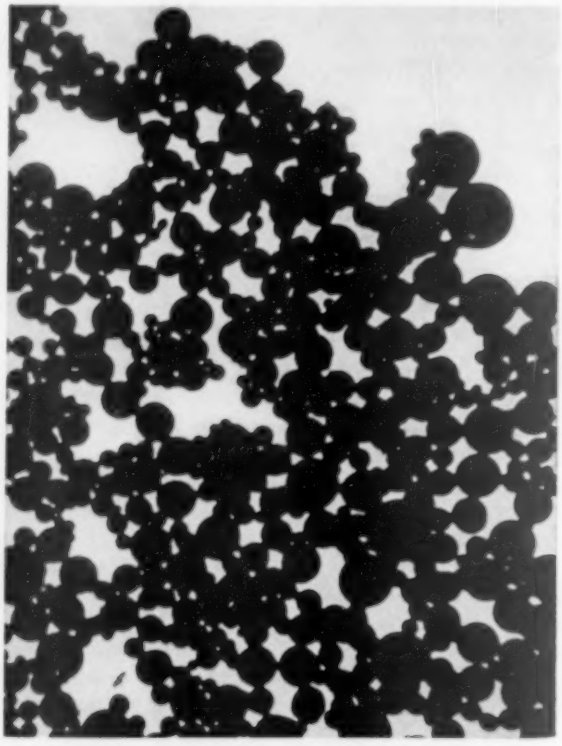

Fig. 5 Rocket sprayed brass particles. (Magnification X 750.) Average particle diameter: about 25 microns. Total gas input: 9 lb/hr at an O_2/C_3H_8 ratio of 4.1:1. Feed rate of $^1/_8$-in. rod: 10 fpm

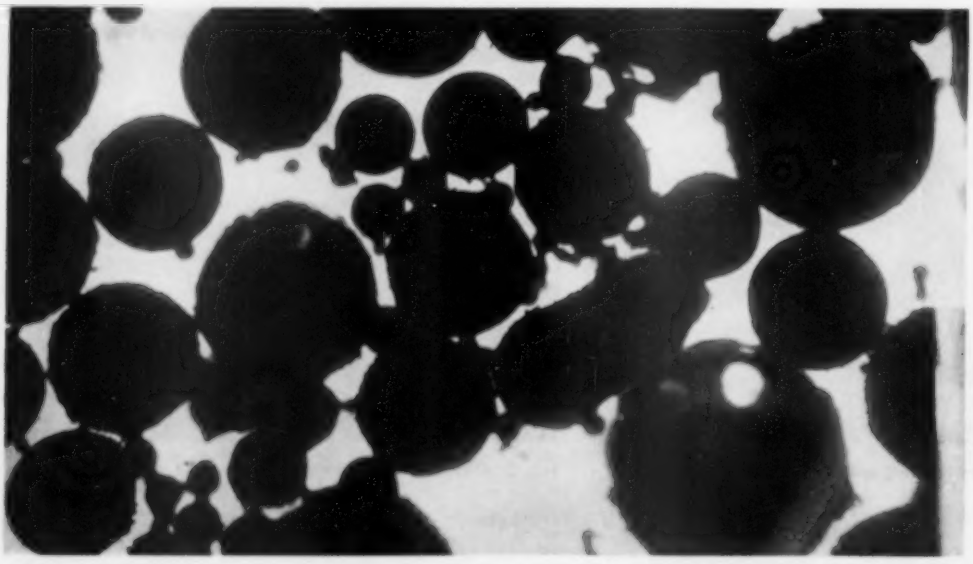

Fig. 6 Average particle diameter: 200 microns. Total gas input: 3.5 lb/hr. O_2/C_3H_8:3.2. Feed rate of $^1/_8$-in. brass rod: 10 fpm

ditions could be restored by increasing the feed rate of the wire. The resulting curves would plot higher on the total gas input axis of Fig. 7.

The wire feed rate, the total gas input, and the oxygen-to-propane ratio may be varied in a given rocket metallizer. If the total gas input is plotted against the oxygen-to-propane ratio for a constant feed rate, metallizing will be possible only within a certain area, or "island," on this graph. Figure 8 illustrates this region.

Less total gas input is required as the oxygen-to-propane ratio is increased to a value slightly greater than stoichiometric. If this ratio is increased further, more total gas input is required for successful metallizing. Finally a ratio is reached at which metallizing will not occur. For relatively small oxygen-to-propane ratios, and for relatively large ratios as well, the total gas input can not be varied over as wide a range as for those of nearly stoichiometric mixture. Since it is necessary to vary the total gas input in order to produce different particle sizes it is best to operate at oxygen-fuel mixtures slightly greater than stoichiometric. On a mass basis the optimum range is between the ratios of four and five.

Experiments were run to determine the extreme conditions at which metallizing of steel wire could be sustained. Metallizing would not occur at oxygen-to-propane ratios less than about three, or more than about eight. The total gas input required to produce a given particle size is greater in the case of an oxygen-to-propane ratio of eight than in the case of a ratio of three. This is due to the fact that an increase in the fuel flow rate to values well above stoichiometric results is less available heat per pound of fluid flowing.

The bond strength of steel sprayed onto a flat surface is shown in Fig. 9 for different oxygen-to-propane ratios as a function of the average particle size of the sprayed steel. This graph indicates that in general the bond becomes stronger with decreasing particle size. This is partially explained by the fact that the surface was prepared for spraying by a very fine grit blast. A strong mechanical bond is encouraged when the sprayed particles are slightly smaller than the cavities in the surface being coated. This is due to the fact that particles will crowd into the cavities to produce interlocks. These interlocks intensify mechanical bonding.

A molecular bond also exists between a sprayed coat and the base surface. This is dependent upon the oxides produced during the spraying operation at the interface of the base metal and the applied coat. Figure 8 suggests that for a given particle size, decreasing the oxygen-to-propane ratio results in a stronger bond. This would indicate that steel oxides are detrimental to the firm bonding of sprayed steel on steel. Decreasing the oxygen-to-propane ratio from 5.0 to 3.5 causes the bond strength to increase 15%.

Conclusion

Metal spraying with rockets is a new process as yet untried in industry. It is believed that this method offers certain advantages over the present commercial air-blast guns. However, a great deal more experimental information is necessary before the advantages and disadvantages of this new process can be fully determined. The rocket metallizer should offer new challenges to industry.

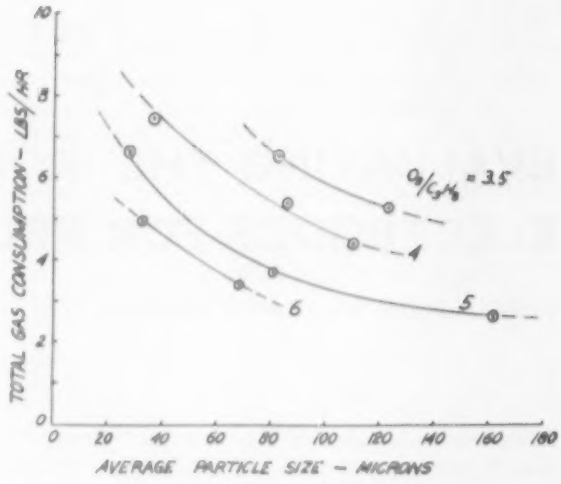

Fig. 7 Average particle size of 1040 steel as sprayed by a small rocket

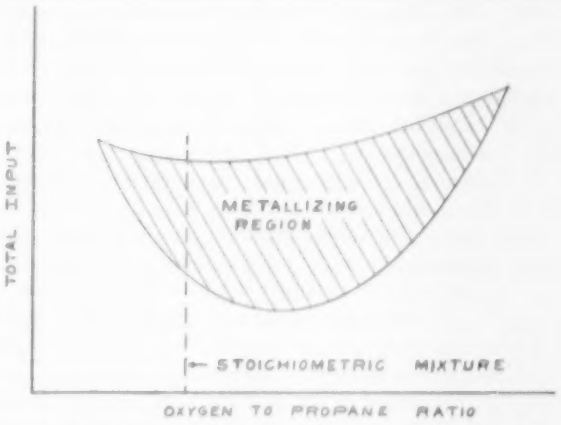

Fig. 8. Region of stable metallizing for a constant wire feed rate

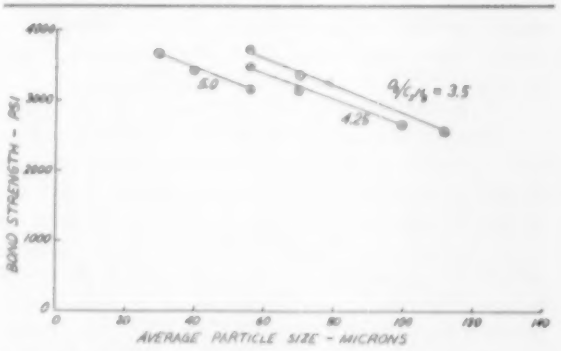

Fig. 9 Bond strength of 1040 steel as sprayed onto a flat surface by a small rocket

EVALUATING THE IRON-POWDER COATED ELECTRODES FOR PRODUCTION USE

DISCUSSION BY JERRY HINKEL

In the August 1955 issue of THE WELDING JOURNAL, Mr. Don Howard's paper on "Evaluating the Iron-Powder Coated Electrodes for Production Use" made some statements which warrant further comment in order to fully present the electrode manufacturer's point of view. The statements involved are in no way questioned or disputed but, we feel, need additional explanation, since they refer to AWS specifications, the significance of which may not be generally understood.

Mr. Howard stated, "Several reputable vendors acknowledge that they check completely each type of electrode they produce against the governing specification, but once a year."

This statement might leave the electrode user with the impression that only periodic effort is made to check the quality of the product. While I cannot speak for all electrode manufacturers, I do know that, in our case, we run complete AWS-ASTM electrode qualification tests only when these tests are actually required to qualify an electrode for a particular classification. These extensive tests are not required for manufacturing quality control, nor are they designed or intended to be an effective method of insuring constant quality. Manufacturers develop their own quality control methods, whose effectiveness is a controlling factor in determining brand differences.

Our quality requirements go beyond the minimum standard requirements of the AWS-ASTM test and are more effective in controlling uniformity of the product. Quality control methods are maintained on all raw materials from the time they are purchased, until the finished product is shipped to the customer. All core wire and chemicals are purchased to very rigid chemistry specifications, and all materials are rechecked when received to make sure that they do conform. Weighing, mixing, extruding and drying are all highly mechanized precision operations involving little possibility of human error. Where there is a possibility of human error, the operation is double-checked to remove all reasonable doubt. In addition to visual inspection, constant checks are made to insure uniformity as to percent coating and moisture. In addition to this, welding tests are made to make sure that the operating characteristics, weld appearance, spatter, etc., are consistent with predetermined standards.

Mr. Howard points out that the AWS-ASTM tests cost his company better than $650, and apparently this was an abbreviated test, omitting some details which were of no concern to ACF; furthermore, the testing covered one electrode size only. If such tests were run as frequently as would be required to give manufacturing quality control, it seems evident that electrode cost would not continue to be the inconsequential part of over-all welding cost which it is today.

In speaking of all-weld-metal tension tests, Mr. Howard said: "The elongation value could only be achieved, however, by incorporating two important technique changes to be used in the preparation of the all-weld-metal tension test specimen; namely, (1) the use of interlayer rather than interpass temperature control, and (2) the incorporation of artificially aging the machined specimen at 200–220° F for 24–48 hr before subjecting it to the tension test." This comment might leave the inference that the values were achieved through unusual techniques.

With reference to the interpass temperature control for each layer rather than interlayer temperature control, this has been the required procedure for military electrode specifications for years (MIL-E-15599).

The procedure simply means that the weldment will be quenched in boiling water after the two stringer beads (one layer) are deposited, rather than to quench the weldment after each individual stringer bead.

By making tests using both methods, we have found that the full weave method is a poorer procedure, especially from the standpoint of obtaining slag-free, porosity-free welds. With certain electrode types, it is virtually impossible to make an X-ray clear weld using the full weave, whereas a split weave will produce much better results. Since X-ray testing is a requirement of the military specification, it seems evident that they have recognized the split weave as the better procedure and specified it for all types of electrodes. However, it is true that in the case of some electrode types, it matters little which technique is used, but we have never seen any results which would indicate poorer weld quality using the split weave.

Paper by **Don Howard** was published in August 1955 issue of THE WELDING JOURNAL, **34**, 752–758.

Jerry Hinkel is Development Engineer, Lincoln Electric Co., Cleveland, Ohio.

The second technique in preparing specimens, namely, artificially aging, also is an accepted and specified practice.

With some types of weld metal, there may be a noticeable difference in the physical properties immediately after welding and after several months aging. Since the user has no control whatever over this change in properties and since weldments are expected to stay in service for prolonged periods of time, it may be important to know just what the properties will be with aging. Extensive testing has shown that exposure of the all-weld-metal specimen at 200–220° F for 24–48 hr will accomplish the same change that would normally occur if the specimen had been aged for a prolonged period of time at room temperature; thus, the aging treatment, as specified in the AWS-ASTM specification, is an accelerated method of determining what the properties of the weld deposit will be after the weldment has been in service for some time.

We hope that these comments will add to the value of Mr. Howard's excellent article on iron-powder electrodes.

AUTHOR'S REPLY

We appreciate Mr. Hinkel's comments on our article published in the August *Journal* and hope that the efforts that have been expended by our company in determining performance factors of these new-type electrodes will result in a consistent and closely controlled product by the electrode manufacturers. Such progress on the electrode manufacturers' part will result in their increased usage as confidence will result in finding new methods and techniques of employing the iron-powder coated electrode.

Mr. Hinkel has referred to effective techniques used by electrode manufacturers in maintaining manufacturing quality control during the fabrication of electrodes. Perhaps some of these techniques could be incorporated into the specification to assure the user that the product, produced under strict control, is also uniform during its use with all of the several important variable factors in balance.

The average electrode user does not usually have the time, men, nor the money to thoroughly evaluate those electrodes in common use in his plant. Such an evaluation program must be judiciously planned in order to make it feasible. Such an expenditure must be sold to management for its endorsement.

Our efforts, with our own end use applications in mind, have conclusively pointed out the magnitude of the effect on elongation of such techniques as interlayer rather than interpass temperature control and artificial rather than natural aging.

We wish to thank those who have cared to hear about this work at their AWS Section meetings, for the intense interest shown, and hope that more users will participate in helping vendors make a better electrode as well as assist the AWS Filler Metal Committee in preparing practical and useful specifications.

Yes . . . in a 12-month period from January 1955 to December 1955, 84,000 reprints of vital articles in The Welding Journal were requested . . . proof of the authoritative editorial calibre of The Welding Journal. Proof, too, of the acceptance by the welding and allied industries of The Welding Journal's high standard of reporting.

HARBOR TUNNEL SECTIONS BUILT ON THE ASSEMBLY LINE

The Maryland Shipbuilding & Drydock Company, which is constructing four of the twin tube sections for the Baltimore Tunnel, has developed an assembly line method of production which is rather unique, practical and efficient (see Figs. 1 through 5). This method of operation eliminates, where possible, standard fabricating procedures normally associated with this type of work.

There will be built a total of 21 double tubes consisting of 42 units of steel casing each 300 ft long and 33 ft in diam. These double tubes will make up the 6300 ft long tunnel which will be one of the longest in the world.

Fabrication of Shell Plating

In the fabrication of the shell or skin plating, the raw material is received adjacent to a channel steel table approximately 2 ft high × 30 ft wide × 260 ft in length. Installed on the table surface are wheel rollers spaced on 2-ft centers throughout its width and length. The use of three 3-ton winches with cable and clamp attachments is required to move three 8 ft wide × $^{3}/_{8}$ in. thick × 52 ft long plates from raw material through a finished 24 ft wide × 52 ft long panel, completely welded ready for additional assembly (see Fig. 1). Special cutting, fitting and welding equipment had to be developed by the yard engineering staff in order to facilitate and efficiently operate this table.

The shaping of the internal framing also presented a problem for manufacturing on a mass production basis. Special steel forms, clamps and mechanical devices had to be developed and used in this operation in order to maintain standard dimensions.

Fabrication of Framing

Standard yard practice which would have been used in the manufacture of the external framing under normal operating conditions was changed because of

Based on a story by the Maryland Shipbuilding and Drydock Co., Baltimore 3, Md.

Fig. 1 Automatic trimming and welding of skin panels forming tunnel half sections

Fig. 2 Assembly and position welding of full tube sections

Fig. 3 Ground view of all welded twin-tube section nearing completion

Fig. 5 Actual launching of completed sections

the multiple numbers of similar type pieces requiring the same operating processes. The complete elimination of individual layout, cutting, etc., was established by the use of jigs, fixtures and special tooling. This change resulted in a far greater increase in efficiency than could have been gained otherwise.

The internal framing is removed from the Fabricating Shop after shaping by a monorail arrangement and is placed adjacent to the form used in the first stage assembly of a typical shell assembly. The skin plate or shell panel, after removal from the process table, is then placed adjacent to the first stage assembly form. The first assembly process consists of positioning and clamping the internal tee frames to the form and lifting the 24 ft wide × 52 ft long shell panel from one end by use of special plate clamps, spreaders and tower crane operation. The bottom of the panel is positioned in the form and clamped, the forward movement of the crane plus the weight of the suspended plate forms itself to the framing to make a completed half shell assembly (see Fig. 2). The half shell assemblies are nested and placed adjacent to the second stage assembly jigs. Each of the two half shell units are positioned on the second stage assembly jig and the two seams plus the tee frame joints are fitted and welded. The second stage assembly jig assures a uniform dimension required in the diameter of each shell unit in order to meet the specification tolerances.

Final Welding Operation

After all fitting and assembly is complete the 33 ft diam × 24 ft long shell unit is removed from the second stage assembly jig and is positioned horizontally in a series of power rolls for the welding operation to be performed (see Fig. 3). The complete structure is welded in the most advantageous position for both quality and quantity by use of this mechanism.

It should be noted that each of the areas of work described beginning with the roller table operation and including the building ways is a straight production

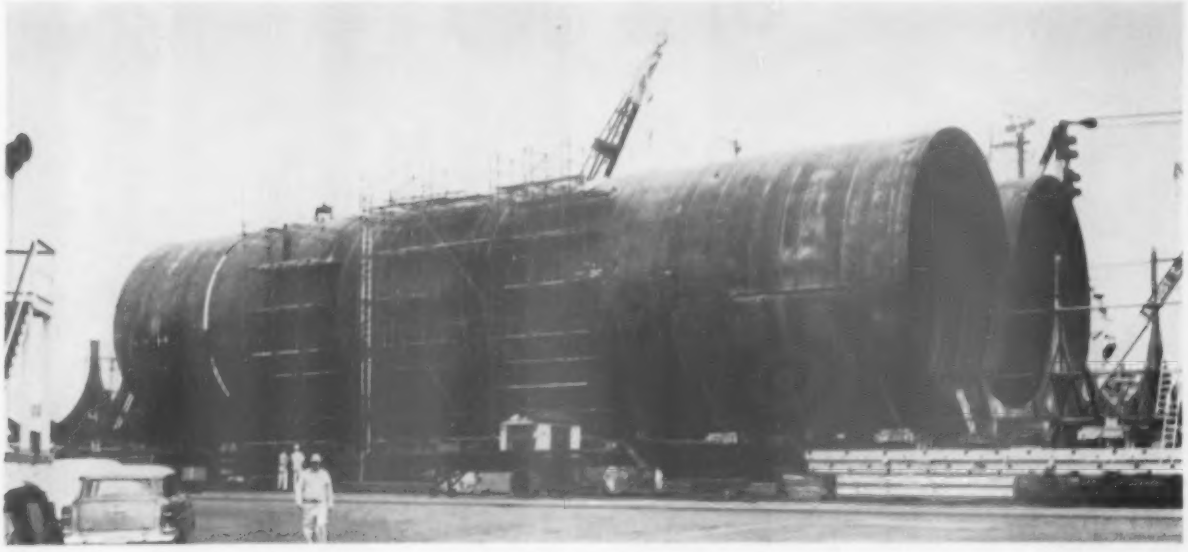

Fig. 4 Nearly completed double-tube sections on the building-way

line covering an area 125 ft wide by 1500 ft long.

The erection and final assembly of the various components are performed on the building ways. The lower external framing which is fitted to the skin or shell plating on 12-ft centers is positioned transversely on three sets of keel blocks or cribbing. Each external frame is levelled, plumbed and braced with sufficient strength to support each 24-ft tube section. The 24-ft tube sections are joined together to eventually make a 300-ft double tube tunnel.

The ends of each tube are closed in order to make the unit watertight. The use of $^5/_8$-in. steel bulkheads serve as a means of preserving the tunnel's watertight integrity but also as a means of joining any two of the 300-ft double tube sections of the tunnel under water. The top half of the external framing and all intermediate framing together with various small assemblies are fitted and welded to the tunnel sections making the tunnel sections ready for the same type of launching as a new ship.

TUNGSTEN-ARC WELDING HELPS RAISE REFRIGERATOR PRODUCTION TO 300,000 UNITS

Automatic inert-gas tungsten-arc welding is helping to cut costs and raise cooler unit production to 300,000 per year for each shift at Hotpoint Co., Chicago, Ill. This is at the rate of one every 24 sec under the present work-shift setup. The complex assemblies consist of type 28 aluminum boxes, tubing, headers and cooling coils (see Fig. 1). All welds are tungsten-arc fusion welds, and require no added rod. Specially designed turning fixtures position and turn the assemblies beneath the electrode holder.

Based on a story by the Linde Air Products Co., New York, N. Y.

The operator simply loads and clamps the parts in the machine, pulls the door over the work and pushes the starter button. The starting of the argon flow, electrical current and turning motor is controlled by a time cycle device which shuts off the equipment when a weld is completed. Welds in small diameter parts take $4^1/_2$ sec or less to complete (see Fig. 2).

Aluminum used in this fabricating job varies in wall thickness from 0.030 up to 0.060 in. Depending upon the part being welded, current ranges from 60 to 140 amp ac.

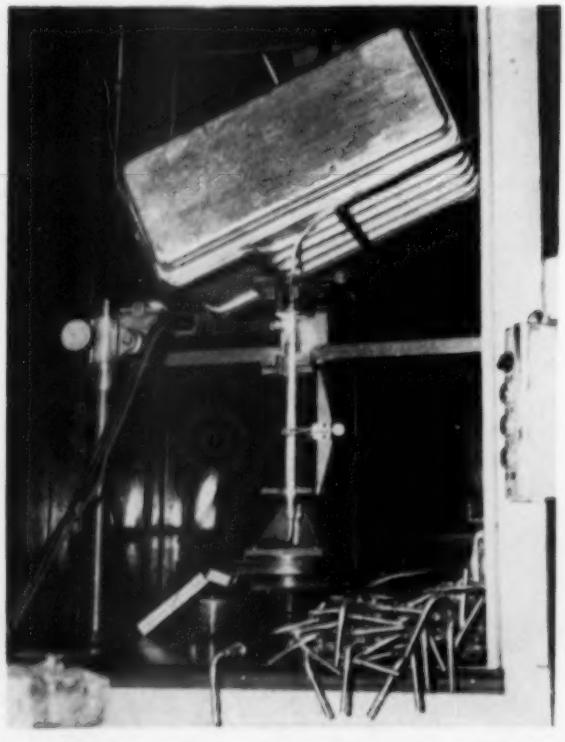

Fig. 1 Welding of this header and evaporator is speeded by an automatic welding setup

Fig. 2 In this automatic inert-gas tungsten-arc welding setup, tubing is welded to a header section in only 4 sec

CUTTING COST WITH SPECIAL WELDING FIXTURE AND AUTOMATIC WELDING

BY A. L. HILL

One of the products fabricated by the Master Tank and Welding Co. of Dallas, Tex. fabricators of LPG pressure vessels, refinery vessels and line pipe, is large diameter heads ranging from 66 to 110 in.

At one time, in fabricating heads from 84 to 110 in. in diam, they followed the usual design, using a dollar plate and five and seven formed pieces, respectively. These were welded inside and out by the manual process, using the proper AWS specified electrodes. Using carbon steel of $^{11}/_{32}$-in. thickness for the 84-in. diam head, this was manually welded in about $9^1/_2$ man-hours.

In an effort to reduce the fabricating time of this product, Master Tank designed and built in their own shop the special welding fixture pictured fabricating one of the larger diameter heads (see Figs. 1 and 2).

After positioning the head on one side and locating the automatic submerged-arc welding head, the fixture is so designed that the operator of the welding head also operates the fixture by push button control and welds the entire inside. Then the head is reversed in the same fixture and, after the welding head is again positioned, the fixture is so designed that the head is moved on a perfect arc to complete the welding on the second side.

The head is first tack welded by hand and then one automatic pass is made from each side completing the welding fabrication. The combination of this special fixture and automatic welding has reduced the welding time on an 84-in. head from $9^1/_2$ hr to 2 hr and on an 110-in. head from 15 hr to 4 hr, which has increased production over 400% with a corresponding saving in labor, grinding, etc.

A. L. Hill is President, Hill Equipment & Supply Co., Dallas, Texas.

Fig. 2 Submerged arc welding the outside head seams

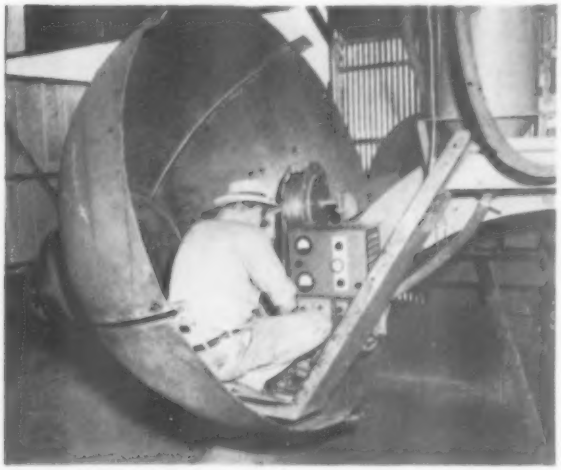

Fig. 1 Submerged arc welding inside seams of a large head after component parts have been tack welded

NEW WELDING RESEARCH FACILITIES UNVEILED BY WORTHINGTON CORP.

A new, fully equipped Welding Research Laboratory was unveiled recently at Worthington Corp.'s Harrison, N. J., Division.

This laboratory is an expansion and extensive improvement of former facilities and is intended to provide the Corporation with increased service in the application of advanced welding techniques to the design and manufacture of Worthington's eleven major products.

One of the most complete research facilities of its kind, the laboratory is equipped with modern welding machines and related metal-working equipment in more than 5000 sq ft of shop space. The welding equipment includes the following units:

1. One d-c single- and two-wire combination automatic welding machine with oscillating attachment—gantry operated. Power is obtained from two 900-amp generators which can be operated in parallel or by single generator through terminal board operation.
2. One a-c electric single- and two-wire combination automatic welding machine with oscillating attachment equipped with third cold wire feed attachment—gantry operated. Power is obtained from three 500-amp a-c transformers which can be operated three parallel, two parallel, or from one single unit through terminal board operation.
3. A gas-shielded metal-arc welding head—combination automatic and semi-automatic gantry operated and provided with a second cold feed wire assembly.
4. Inert-gas tungsten-arc welding equipment.
5. A 60-kva resistance spot-welding unit.
6. Stud-welding equipment.
7. A stress-relieving furnace, and gas-fired preheating box.
8. Two 2500-lb and one 6000-lb welding positioner.
9. An automatic welding gantry manipulator table.
10. Two submerged-arc semiautomatic welding machines.
11. One oxygraph torch - cutting machine—two torches and magnetic torch.

Fig. 1 A 2500-lb. welding positioner equipped with automatic inert-gas metal-arc welding machine

Fig. 2 An automatic 2-wire submerged-arc welding head modified for cold wire additions with oscillating head. View shows 2-wire head being used to weld girth butt seam of a compressor housing

Fig. 3 Stud welding by use of templet fixture. In background, a semiautomatic submerged-arc welding operation being used to weld a longitudinal butt joint in a compressor housing

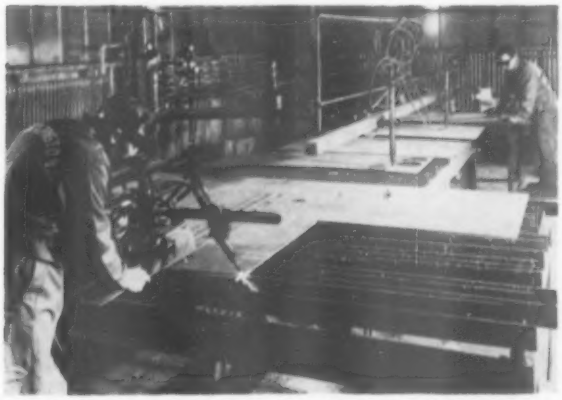

Fig. 4 Torch-cutting table with radiograph cutting machine and an oxygraph torch-cutting machine

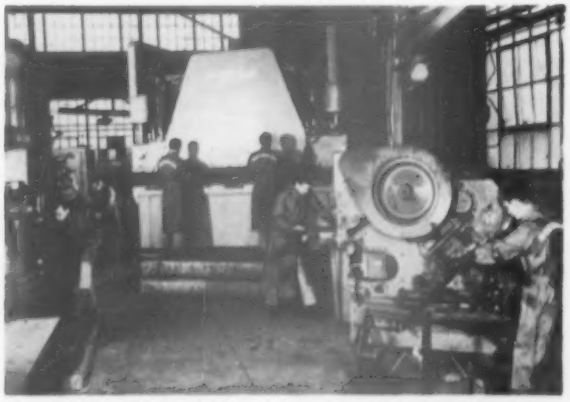

Fig. 5 Part of the fabricating section: large unit in center is a 300-ton hydraulic press brake.

12. A torch-cutting table with radiograph cutting machine.

The functions of this laboratory are in four major categories:

1. Designing and building models or full-scale test weldments.
2. Designing and building special welding machines.
3. Developing new welding techniques and procedures, and testing commercial materials and equipment.
4. Training welding engineers, designers, shop supervisors, and operators.

The new facility, then, will be used for welding application research, designing for welded construction, and building of prototype models.

The shop equipment was designed for maximum working convenience. An overhead 10-ton cab-operated crane covers the entire floor area in addition to a 2-ton and three 1-ton jib cranes. These and other facilities are available for fabricating and welding structures up to 10 tons; a unique automatic welding manipulator and tilting floor is conveniently located in a nearby shop. The table for this machine is 18 x 33 ft and weighs 65,000 lb. It is one of the largest installations of its type in the country.

Laboratory also includes locker room, lecture room, and a design engineering office.

Society News

American Welding Society Elects New Officers

John J. Chyle

John J. Chyle, Director of Welding Research, A. O. Smith Corp., has been elected President of the AMERICAN WELDING SOCIETY for the 1956–57 fiscal year beginning June 1.

The other new officers are:

First Vice-President—Clarence P. Sander, General Superintendent, Vernon Plant, Consolidated Western Steel Div., United States Steel Co.

Second Vice-President—Gustav O. Hoglund, Head of Welding Section, Alcoa Process Development Laboratory, Aluminum Company of America.

The following will serve as Directors-at-Large:

John H. Blankenbuehler, Design Engineer, Hobart Brothers Co.; George E. Linnert, Charge of Welding Research, Research Laboratories, Armco Steel Corp.; Gordon Parks, Chief Welding Engineer, Solar Aircraft Co.; Francis H. Stevenson, Production Engineer, Aerojet-General Corp.

The following will serve as District Directors:

Middle Eastern (District 2)—Donald B. Howard, Supervisor of Metallurgy and Welding, Research and Development Department, American Car and Foundry, Division of ACF Industries, Inc.

Southeast (District 4)—Thomas R. Berg, Registered Inspector, J. Calvin Jureit & Associates.

Central (District 6)—Keith Sheren, Sales Engineer, Taylor-Thompson Machinery Co.

Midwest (District 8)—Frank G. Singleton, Owner, Singleton Welding Supply Co.

Western (District 10)—Charles L. Breese, President, John Tillman & Co.

Clarence P. Sander

Gustav O. Hoglund

DIRECTORS AT LARGE

John H. Blankenbuehler

George E. Linnert

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Francis H. Stevenson

DISTRICT DIRECTORS

Donald B. Howard
District No. 2

Thomas R. Berg
District No. 4

Keith Sheren
District No. 6

Frank G. Singleton
District No. 8

Charles L. Breese
District No. 10

Continuing in Office

In addition to the newly elected candidates, the following national officers will continue completion of their terms, sharing the responsibility of guiding the destinies of the AMERICAN WELDING SOCIETY during the 1956–57 fiscal year:

Honorary Life Director: Comfort A. Adams; *Treasurer:* R. S. Donald; *Directors-at-Large:* R. W. Clark, J. W. Mortimer, E. D. Peters, H. Savage, R. L. Townsend, J. L. Wilson and R. J. Yarrow; *District Directors:* S. Low (No. 1), C. E. Jackson (No. 3), A. F. Chouinard (No. 7), J. B. Davis (No. 9), C. M. Styer (No. 11); *Junior Past Presidents:* C. H. Jennings, F. L. Plummer and J. H. Humberstone.

TAC TALKS

Prohibition—Welding Iron Castings—And Its Repeal

J. S. Vanick

Engineers have not felt free to entrust the welding of iron castings to their processors.

Casting defects may involve as much as 10% of a shop's production. With foundry labor reaching a value of $5 to $50 per man-machine hour, a 90% achievement of perfection still leaves an important 10% margin for salvage and reclamation.

The purchaser is entitled to a good serviceable casting. Should a $20 casting sell for $22 and the unforseeable scrap be charged off—or would both producer and consumer make a profit if small defects were repaired and castings salvaged to sell for $21 each?

Many integral foundry and manufacturing units establish the rules for casting rejection, and corresponding regulations for repair and salvage. But diverse suppliers, funneling their output into a common manufacturing line, encounter difficulties between casting and manufacturing units. Excellent welds may be made by skilled workmen, but irresponsible and reckless elements in both the welding and foundry industries may, through their inexperience, patch and paste metal over defects. This brings about the industrial delinquency that leads to the prohibition "castings shall not be welded. . ." Most economics-minded engineers would admit that the salvaged product could creditably serve if properly reclaimed by welding. Here is where the rules must be laid down and compromises made between perfection and satisfaction. To this objective, a Joint Committee of American Foundrymen's Society and AMERICAN WELDING SOCIETY members has committed itself.

About a year ago a Joint Committee of the American Foundrymen's Society and the AMERICAN WELDING SOCIETY was formed to undertake a survey and study of the welding of iron castings. Several meetings have been held, and progress can be reported. A report of this character is scheduled to be presented at the Annual Meeting of the American Foundrymen's Society in Atlantic City on the morning of May 4, 1956, at a location to be designated in the A.F.S. program. The occasion will provide an opportunity for segments of the Joint Committee to report briefly upon their activities and invite questions or discussion from those who may attend.

Bibliographies on the general subject of welding iron castings have been sub-

J. S. Vanick is Chairman, AWS-AFS Committee on Welding Iron Castings; Development and Research Division, International Nickel Co., Inc.

mitted by both A. F. S. and A. W. S. The committee immediately found itself confronted with the need to define such common terms as "salvage," "repair," "reclamation" and "fabrication" as related to iron castings. Definitions were proposed by a Subcommittee headed by George A. Meyer, Jr., of the Malleable Founders Society. Tentative specifications for filler metal were brought in by another group headed by H. V. Inskeep of the Linde Air Products Co. A report upon "Test Block for Welding Cast Iron," prepared by members of the Allis-Chalmers Co. staff, was received for the committee's consideration. Another subcommittee has been organized to survey existing practice for the repair welding of castings at operating shops, so that every element of skill which is now available can be recorded for classification and promotion into accepted practice.

An outline of topics for study on the welding metallurgy of iron castings was submitted by Bela Ronay of the U. S. Naval Engineering Experimental Station, acting for his subcommittee. An outline of work on inspection and testing was submitted by another subcommittee. Sidney Low of the Chapman Valve Manufacturing Co., submitted an outline of information on physical and mechanical properties of cast iron welds which his subcommittee has begun to assemble. In this connection, he has openly invited foundrymen or those in the welding industry who have data of this character, to write him directly regarding its availability. The work of this committee is of extreme importance to foundrymen where salvage operations in foundry production may affect as much as 10% of the output. For the welding industry the problems of producing successful repairs and extending the practice to fabrication, invites the utmost in skill and resourcefulness to advance the art of welding iron castings. The repair of worn or broken castings is of lesser importance to the foundryman but, in contrast, it represents a major activity in welding shops, particularly in connection with the return to service of large or expensive castings.

The work for this committee was initiated through the objection to welding which exists in many commercial and government specifications. The repeal of prohibitions against welding requires that foundrymen and the welding industry establish a code of self-regulation that will minimize the need for enforcement by others in the metal-consuming community. The Joint Committee expects ultimately to arrive at definitions, specifications and recommended practices for welding iron castings. It invites the participation of foundrymen, engineers and all others interested in castings and welding to help in achieving its objectives.

Three Supporting Company Members Added by AWS

Three additional Supporting Company Member Enrollment Applications have been received recently by the AMERICAN WELDING SOCIETY. The applying organizations are as follows:

Modern Engineering Co.
3401-15 Pine Blvd.
St. Louis 3, Mo.

Scranton-Spring Brook Water Service Co.
30 N. Franklin St.
Wilkes-Barre, Pa.

Weltronic Co.
19500 W. Eighth Mile Rd.
Detroit, Mich.

These new membership enrollments became effective on April 1st.

Midwest District to Hold Annual Conference

The District 8 (Midwest) annual conference will be held in Minneapolis, July 20th and 21st, this year, during the famous Minneapolis Aquatennial week with the Northwest Section as host.

Officers from seven midwest Sections will participate in this conference. Russell H. Schleuder of Electric Machinery Manufacturing Co. is general arrangements chairman and a full and complete two-day program is scheduled for members attending with their wives and friends.

Sections participating in this District 8 conference are Iowa (Des Moines), Nebraska (Omaha), St. Louis, Kansas City, Wichita, Colorado (Denver), and Northwest (Minneapolis).

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Many Important Topics Discussed at District No. 7 Meeting in Chicago

The Executive Committee of AWS District No. 7, the West Central, met in Chicago on the evening of February 1st in the Conference Room of the Armour Research Foundation.

Among those in attendance were First Vice-President J. J. Chyle; National Secretary J. G. Magrath; District No. 7 Director A. F. Chouinard; several officers of the Chicago, Fox Valley, Iowa-Illinois, Madison and Milwaukee Sections; and representatives of ARF.

Many topics of general interest were discussed at the meeting, including the following: (1) the idea of scheduling outstanding speakers for a single trip; (2) membership drives; (3) a proposal that letters be written to top management suggesting that they have their technical people visit AWS Section Meetings; (4) the advantages and disadvantages of having "coffee speakers" at these meetings; (5) best type of meetings to be held; (6) type of program announcements to be used; (7) need for dinners prior to technical meetings; and several other related topics.

This meeting proved so successful and constructive, that it was proposed to hold a similar session sometime in the Spring.

WEST CENTRAL DISTRICT EXECUTIVE COMMITTEE MEETS AT ARMOUR RESEARCH FOUNDATION

Seated around the dinner table at the February 1st meeting of the Executive Committee of District No. 7 are, in a clockwise direction: H. Schwartzbart, A. C. Mulder, J. H. Stevens, E. Hart, J. J. Chyle, O. T. Barnett, J. Wiegand, A. F. Chouinard, J. Revelt, J. K. McDowell, R. R. Lincoln, J. G. Magrath, J. Bland and E. Zahumensky. Also present at the meeting, but not shown above, were C. Drutzler, F. H. Harencki and A. L. Schaeffler

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Students Addressed by Dato

On the evening of February 27th, J. E. Dato [illegible], assistant manager, Welding, of the Linde Air Products Co., N. Y., spoke before the *California State Polytechnic College* Student Chapter in San Luis Obispo, Calif. His subject was inert-gas welding and cutting. The arc cutting of aluminum is a recently developed process and, consequently, a great deal of interest was aroused by this discussion. Mr. Dato also outlined the many new developments in welding that he had seen on his many trips throughout the country.

DATO SPEAKS BEFORE STUDENT CHAPTER

Guest speaker Ed Dato *(second from the left)* is shown at the February 27th meeting of the California State Polytechnic College Student Chapter commenting on an aluminum specimen cut by the inert-gas tungsten-arc process. Interested listeners are *(left to right)* Chairman Carl T. Schmid and Secretary-Treasurer John Bartley, and Robert Frick of the Linde Air Products Co.

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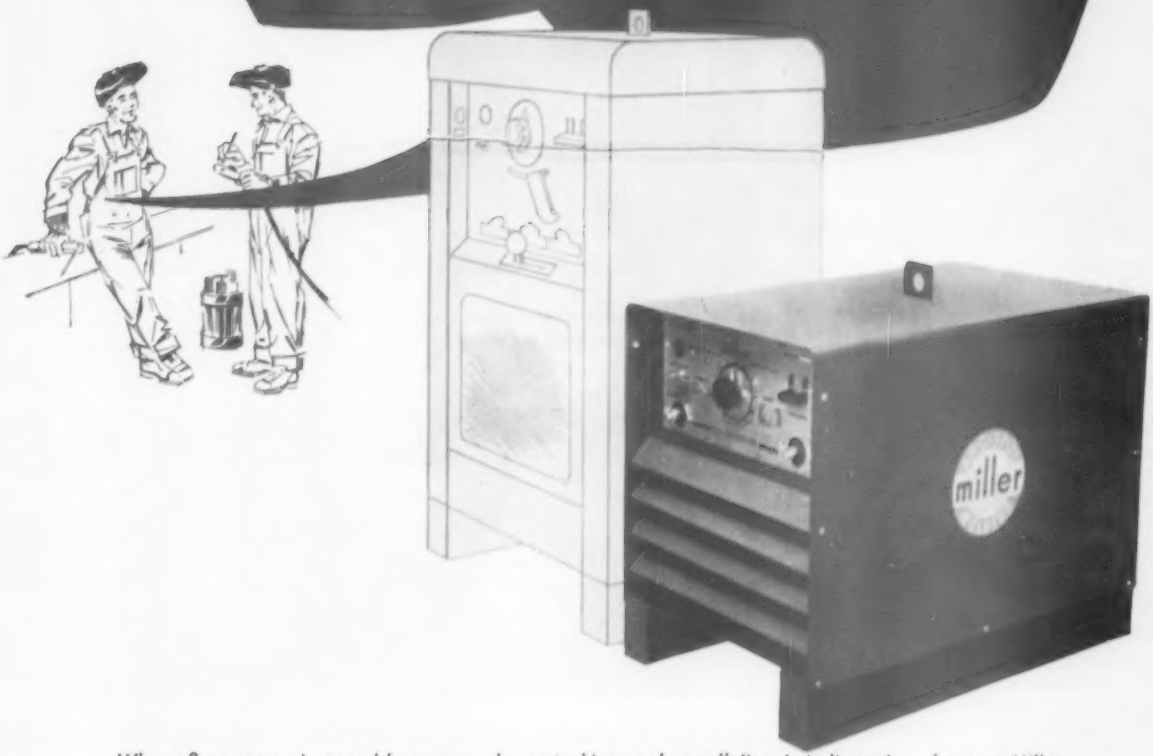

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Section News and Events

as reported to Catherine O'Leary

QUIZ PROGRAM

Fort Wayne, Ind.—The regular monthly meeting of the *Anthony Wayne* Section was held on March 16th at the Van Ornam Hotel, starting with a dinner and followed by a quiz program. Five teams each consisting of four members represented the following Sections: *Indiana*, Captain, Ray Wirt; team members, Ed Holt, C. Hofferman and Mike Schaefer. *Michiana*, Captain, W. G. Fassnacht; team members, Don Kyler, Harry Hale and Floyd Doolittle. *Detroit*, Captain, Jack Lemon; team members Gerald Wilson, George Motzenbecker and Al Last. *North Central Ohio*, Captain, Giles Howell; team members, Ken Showalter, Walt Edwards and Joe Henne. *Toledo*, Captain, Sam Snell; team members, John DeWitt, Merle Baughman and Kenneth Welty. There were three judges from the Anthony Wayne Section, namely, D. Rice, George Laws and Kenneth Zimmerman. Harry Johnson was the moderator.

Questions were drawn in rotation. The field of welding was very well covered, in arc, spot, resistance, and inert-arc welding. A true or false set of questions were presented. The moderator presented questions that brought out a lot of discussion, which was of great benefit to all present.

A plaque was awarded to the winning team from the Detroit Section; its members had a score of 570 out of a possible 700.

PLANT TOUR

Montevallo, Ala.—On Tuesday evening, March 13th, the *Birmingham* Section sponsored a visit to the new Westinghouse Welding Electrode Plant at Montevallo, Ala. The trip was very interesting for those who boarded the buses provided by Westinghouse and for others who made their way to the plant by private car. Approximately 150 men from all branches of industry around Birmingham took part in this plant visitation.

The plant was in full operation and all phases of electrode production could be observed.

Sincere thanks are extended to the

QUIZ NIGHT HELD BY ANTHONY WAYNE SECTION

Some of the members who attended the March 16 meeting of the Anthony Wayne Section are shown here during dinner

Section Chairman Dudley Rice (*extreme left*) is shown soon after presenting plaque to the winning Detroit team: (*left to right*) Jack Lemon, Gerald Wilson, George Motzenbecker and Al Last

SECTION MEETING CALENDAR

MAY 18

CLEVELAND Section. 17th Annual Symposium. Hotel Manger, Cleveland, Ohio. 2:00 P.M. Registration starts 10:30 A.M.

INDIANA Section. Buckley's Restaurant, Cumberland, Indiana. Annual Election of Officers. Speaker on Silver Brazing Alloys.

MAY 22

OLEAN-BRADFORD Section. "Inert Arc Welding," by W. T. Davis, Air Reduction Sales Co.

JUNE 9

CHICAGO Section. Golf Outing. Details later.

COLUMBUS Section. Family Night. Holiday Hill, Delaware, Ohio.

JUNE 19

DAYTON Section. Annual Picnic. 5:00 P.M. Inland Activities Center.

Editor's Note: Notices to be published in any one given issue must reach Journal office prior to the first of the preceding month. Give full information concerning time, place, topic and speaker for meeting.

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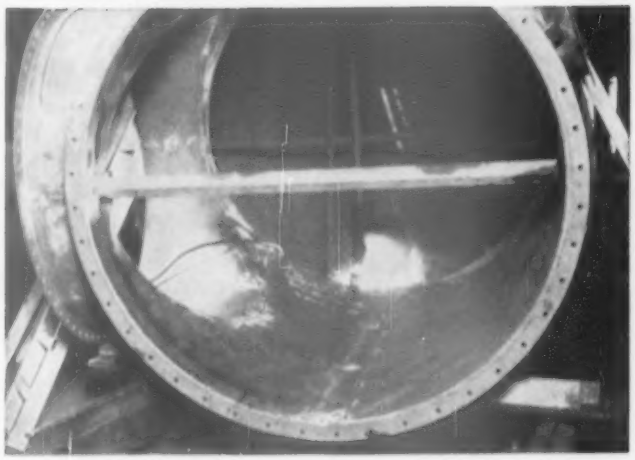

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Westinghouse management for the plans made to make this trip so successful.

MAINTENANCE WELDING

Bridgeport, Conn.—The regular monthly meeting of the *Bridgeport* Section was held on March 22nd at Rapp's Restaurant in Shelton. Speaker was L. D. Richardson [illegible], of the Eutectic Welding Alloys Corp., Flushing, N. Y. His subject was "Maintenance Welding." After his talk, Mr. Richardson engaged in a question-and-answer session to the satisfaction of all.

ANNUAL SYMPOSIUM

Cleveland, Ohio—The *Cleveland* Section's 17th Annual Symposium will be held at the Hotel Manger on May 18, 1956. Registration will start at 10:30 A.M., and the technical program will begin at 2:00 P.M. Technical Chairman, will be Frank Flocke, The Thornton Co. The speaker at 2:00 P.M. will be R. A. Noland, assoc. metallurgist, Argonne National Laboratory, Lemont, Ill. His subject will deal with "Welding Problems in Nuclear Reactors." The speaker at 2:30 P.M. will be F. J. Bockhoff, assoc. director of research and development, American Agile Corp. His subject will be "Welding of Plastics." The third speaker at 4:00 P.M. will be R. W. Emerson, chief metallurgist, Pittsburgh Piping & Equipment Co., who will talk on "Welding Austenitic Stainless Steel for High Temperature Service." The banquet will get underway at 6:30 P.M. The evening speaker, at 8:00 P.M., will be Lawrence Hall, whose subject will be "Humor—A Resource."

CARBON DIOXIDE WELDING

Cleveland, Ohio—The March 14th meeting of the *Cleveland* Section, held at the Hotel Manger was featured by a fine talk by Edward J. Vogel of the Liquid Carbonic Corp. Mr. Vogel discussed "CO_2 in Welding," a topic which proved of the utmost interest to the many members present.

Mr. Vogel pointed out, among other things, that CO_2 welding is growing in demand and that an increasing number of organizations are using this process on mild steel with good results. He also stressed that, with proper application, substantial savings in cost can be realized. Deep penetration, high-welding speed and no need for flux were cited as advantages by the speaker; spatter and erratic arc were some of the disadvantages.

The coffee speaker of the evening was D. Farrell, of Postal Inspection. He dealt with "Criminal Aspects of the Postal Laws," and his subject was found very informative.

QUENCHED AND TEMPERED STEEL

Denver, Colo.—An attendance of 60 members and guests of the *Colorado* Section were present at dinner held in the Festival Room of the Oxford Hotel on March 13th.

The speaker at the technical session following the dinner was Leon C. Bibber, [illegible], chief research engineer, Welding, U. S. Steel Corp., Pittsburgh.

Mr. Bibber's talk on "The Suitability of Quenched and Tempered

RESISTANCE WELDING IS TOPIC AT COLUMBUS SECTION MEETING

General view of dinner held at March 9th meeting of Columbus Section

These are the members of the panel who discussed resistance welding problems. Standing left to right are: Paul Speer, Jack Lott, R. C. McMaster, R. Warrender, R. Rasmussen, W. Roboski. Seated are: A. Carasso, C. R. Schroder (guest speaker), C. LaPlant and F. Williamson

Dean G. B. Carson of Ohio State University is shown awarding conference certificate to Robert Yanks. At right are Professor R. C. McCauley and J. Brockmeyer, chairman

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Steel for Pressure Vessel Construction" was handled very effectively and was accompanied by slides and motion pictures.

RESISTANCE WELDING FUNDAMENTALS

Columbus, Ohio—Friday, March 9th, was a big night for the *Columbus* Section as Dean Gordan B. Carson, College of Engineering, Ohio State University presented 67 certificates to men who completed "Conference Course in Resistance Welding Fundamentals" presented by the Department of Welding Engineering of the College of Engineering, Ohio State University and sponsored by the Columbus Section of the AMERICAN WELDING SOCIETY. Since a total of 108 attended the course, the remainder will be mailed their certificates.

Following the dinner and presentation of the Welding Conference Course Certificates, C. R. Schroder, vice-president in charge of Operations, Weldaloy Co. talked on "Resistance Welding Electrode Alloys—Fundamentals of Application." Following Mr. Schroder's talk there was a panel discussion in which panel members answered questions submitted from the floor pertaining to "Resistance Welding Problems."

The panel moderator was: Dr. R. C. McMaster, Ohio State University. The panel members were: Jack Lott, North American Aviation; Clarence LaPlant, Clark Grave Vault Co.; Paul Speer, Surface Combustion Corp.; Walter Roboski, General Motors Corp.; Raidar Rasmussen, Battelle Memorial Inst.; and Ralph Warrender, Westinghouse Electric Corp.

SYMPOSIUM MEETING

Dayton, Ohio—The March meeting of the *Dayton* Section held on March 13th was in the form of a symposium on recent developments in resistance welding techniques and equipment.

Moderator for the meeting was Carl Bertsche who first spoke briefly on the need for research and then introduced the two speakers.

William E. Klingeman AWS, of the Precision Welder & Flexopress Corporation of Cincinnati, talked on the general approach of research in welding and fully explained one problem in eliminating a "bounce" in ram force of magnetic welder, solved by the use of a high-speed camera. His presentation was illustrated by movies.

F. R. Woodward AWS, The Taylor Winfield Corp., Warren, Ohio, discussed research as it applies to creative approach in the adding of automation to welders and in developing suitable production electrode conditions. Movies of gas tanks and compressor seam welding were shown.

WELDING METALLURGY

Dayton, Ohio—A meeting of the *Dayton* Section was held on February 14th at the Dayton Engineers Club.

The speaker, Austin Hiller AWS, manager, production planning and marketing research, Welding Department, General Electric Co., York, Pa., presented, by engineering analysis and slides, a good case for influencing designers to approach joint and section designs with basic design equations set up for maximum strain rather than conventional stress. The title of Mr. Hiller's talk was "Basic Problems of Welding Metallurgy."

WELDING STAINLESS STEELS

Detroit, Mich.—"Welding of Stainless Steels" was the subject of the March meeting of the *Detroit* Section held on March 9th in the ESD Rackham Building. One hundred and five members and guests attended the meeting, which was addressed by D. W. McDowell AWS, of the International Nickel Co., New York. The speaker drew on his varied background as a teacher, industrial metallurgist, and as a Naval Officer, to cover this interesting and involved subject. Audience interest was particularly high and it was evident that time and other limitations left the group anxious to continue to explore this subject. Since 1953, Mr. McDowell has been working as a metallurgist in the Stainless Steel and Heat Resistant Alloys Section of the Development and Research Department.

TALKS ON STAINLESS STEELS

D. W. McDowell discussing welded stainless steel specimens with members of the Detroit Section

SIMPLIFIED METALLURGY

Appleton, Wis.—A. L. Schaeffler AWS, of the Welding Research Department, Allis Chalmers Manufacturing Co., discussed the metallurgy of welding at the February meeting of the *Fox Valley* Section held on February 17th at the Elks Club.

His talk, which was well illustrated by slides showing phase diagrams for mild, low-alloy, and stainless steels, was simplified by use of colored cartoons which enabled the audience to easily understand what generally is a rather technical subject.

Seventy-five members and guests were present for the discussion which was followed by a question period and then refreshments.

GAS APPLICATIONS

Hartford, Conn.—Owing to travel difficulties created by the 24 in. of snow which had fallen in the Hartford area, the March meeting of the *Hartford* Section held on March 20th at the Villa Maria in Glastonbury was attended by only 16 hardy members from the area.

Speaker at the meeting was J. S. Douglass AWS, who is manager of engineering services of the New England offices of the Linde Air Products Co., Boston. Mr. Douglass discussed the "Handling and Usage and Applications of Oxygen and Acetylene." He described the equipment used in scarfing of blooms and sizers in steel mills, shape cutting, and the cutting of marble in quarry works.

RESISTANCE WELDING PROCESSES

Cumberland, Ind.—The regular monthly dinner meeting of the *Indiana* Section was held on February 24th at Buckley's where fried chicken served country style, was featured.

Technical speaker was W. G. (Jerry) Fassnacht AWS, assistant chief metallurgist at Bendix Products Division, South Bend. Mr. Fassnacht talked on resistance welding processes for automotive and aircraft components.

Covered were equipment, process and welding metallurgy on many specific assemblies fabricated by the resistance welding process. Welding metallurgy on many alloy steels was discussed. A lively question-and-answer period followed.

A film was shown entitled, "Steel for the Ages" showing the manufacture and fabrication of stainless steels.

About fifty members and guests attended.

FUTURE OF WELDING

Cumberland, Ind.—T. B. Jefferson [illegible], editor and publisher of the *Welding Engineer*, was the speaker at the January 27th dinner meeting of the *Indiana* Section held at Buckley's Restaurant in Cumberland.

The subject of Mr. Jefferson's talk was "What the Future Holds for Welding."

Mr. Jefferson gave some of the historical aspects of the art of welding, and discussed how welding has come of age over the past forty years. It was inspiring to hear Mr. Jefferson describe how unrelenting effort is constantly promoting the acceptance of welding by the formulation of more realistic codes, standards, etc., and the probable unrestrained use of welding in bridges, ships, buildings, etc., in the future.

About fifty members and guests attended.

SUBMERGED ARC WELDING

Moline, Ill.—The March meeting of the *Iowa-Illinois* Section was held on March 8th at the American Legion Club in Moline. A social hour and dinner preceded the meeting.

Featured speaker was R. A. Wilson [illegible] of the Applications Engineering Dept., Lincoln Electric Co., Cleveland, Ohio. Mr. Wilson's talk was "New Developments in Submerged Arc Welding." However, this subject was hardly indicative of the complete coverage that the speaker gave to the submerged-arc welding field.

With the aid of slides, the speaker pointed out the factors which govern the usability of "semi" or "automatic" in the choice of equipment. Mr. Wilson's comprehensive and detailed outline of welding procedures, type of equipment, controls and power sources was well received by a very attentive audience.

PLANT TOUR

Paola, Kan.—In March, the *Kansas City* Section once again took to the road and traveled by Greyhound Bus to Paola, Kansas for a tour through the Metal Manufacturing Division of the Fluor Products Company. Dinner and refreshments were provided through the generosity of the Fluor Corp. After dinner, Clyde Hull, general manager, welcomed the visitors.

Fluor prefabricates pipe and pressure vessels in all sizes and alloys, heavy duty mufflers and pulsation dampening systems, tanks and towers, air-cooled heat exchangers, structures, etc. They weld carbon and alloys, steels, aluminum and other metals. They use automatic and manual welding equipment and techniques. On the tour, the Section members saw flame cutting machines of several designs, automatic welding machines, as well as a battery of arc-welding machines, inert-gas shielded-arc processes, etc. Also, bending, testing, heating and machinery operations were witnessed.

This plant is a fine tribute to modern welding methods and techniques, and the Section members enjoyed the opportunity for making this plant tour.

The tour took place on March 22.

Members having dinner at Eagles Lodge prior to visiting the Fluor plant on March 22nd

Harry Rogers, quality control supervisor for Fluor, explaining the production and functions of extrusions

FLUOR PRODUCTS CO. PLANT TOURED BY MEMBERS OF KANSAS CITY SECTION

Automatic welding machine in the Pipe Shop draws much attention

Welding of head to shell seam being explained by Don Miller (*left*), Plate Shop foreman

Mr. Rogers (*extreme right*) is shown discussing the application of X-ray machine

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RESISTANCE WELDING APPLICATIONS

Hyde Park, Calif.—Members and guests of the Aircraft and Rocketry Panel of the *Los Angeles* Section met on March 1st at the Elks Lodge in Hyde Park and had the pleasure of hearing Joseph H. Cooper [AWS], chief sales engineer for the Taylor Winfield Corp., of Warren, Ohio, present an outstanding paper on resistance welding applications.

Out of the many applications in different industries dealing with different metals for resistance welding processes, Mr. Cooper pointed out, there are always a few which are outstanding in being somewhat different or unusual and requiring different methods of approach than a conventional one.

Mr. Cooper presented, with the use of slides, a series of case histories of a few such applications showing the intricacies encountered in all types of fabrication done by resistance welding and how they are overcome by the use of specially made and designed mobile units for spotwelding, special wheels for seam welding, indexing fixture, etc. Also, he described the welding of terminals on a production basis, the type of equipment required, the making of titanium engine valves at a high-production rate by automatic resistance methods of hot upsetting; showed and explained in detail the mechanisms and functions of the type of machinery required, small roll seam welders, such as required for making bellows of light-gage stainless steel materials and fixtures that automatically adopt themselves to the process such as required by the aircraft industry. Mr. Cooper also showed and explained how an exceptional duty cycle was obtained by a subcontractor by the use of attached wheel dressing equipment in the resistance welding of drop tanks on a production basis.

Mr. Cooper's subject was well covered and can be considered one of the most interesting ever presented in the resistance field.

A colored film was presented showing the automatic mechanized line that is used in the automotive industry for the resistance welding of tank halves, brake drums, etc. This was narrated by Mr. Cooper.

In conclusion, Mr. Cooper was presented with a pen set in appreciation of his time and efforts.

Prior to Mr. Cooper's presentation, Harlan Meredith, chairman of the Aircraft and Rocketry Panel presented two special guests of the evening— Mr. and Mrs. Sharp from Edwards Air Force Base, who made the trip in from the desert to enjoy the occasion. Mrs. Sharp was later selected to draw the door prizes which were won by none other than our vice-chairman, Mario Ochieano of Lockheed Aircraft and Jerry Garfield, member of the Executive Committee. This was a first time for both parties.

SPEAKS ON RESISTANCE WELDING

Joe Cooper was the guest speaker at the March 1, 1956, meeting of the Aircraft and Rocketry Panel in Huntington Park, Calif.

WELDING DISSIMILAR METALS

Louisville, Ky.—President J. H. Humberstone [AWS], gave an interesting and inspiring talk on the activities of the Society and outlined several plans for future improvements at the dinner meeting of the *Louisville* Section held on February 28th at the White Cottage Restaurant.

Featured technical speaker was M. D. Bellware [AWS], of the International Nickel Co., N. Y., who discussed the welding of dissimilar metals.

METALLIZING

Madison, Wis.—A highly successful meeting of the *Madison* Section was held on March 22nd at the Morse Hills Country Club in Beloit.

Coffee speaker was Ed Gharrity, former Washington Senator catcher who gave an interesting picture of baseball as it is today and how it contrasts with yesterday's style of play. The group was well pleased with Mr. Gharrity's remarks. Technical speaker was Richard Sitman of the Metallizing Engineering Co., Chicago, Ill. Mr. Sitman's address on "Metallizing" gave excellent proof of his

personal knowledge of metal spraying. Many interesting and unknown facts concerning this process were brought to light in a short verbal summary before the movie. Mr. Sitman attempted to explain the limitations of metal spraying in regards to a decision by the operator whether or not he should use conventional weld build-up or resort to the metallizing application.

A movie which followed substantiated Mr. Sitman's initial address. A sound track was available on the film and blended in smoothly with the colored photoplay.

SUBMERGED ARC WELDING

Baltimore, Md.—The March Meeting of the *Maryland* Section was held Friday, March 16th, at the Engineer's Club, 6 W. Fayette St., Baltimore, Md.

The Technical Speaker for the evening was Robert (Bob) Wilson [illegible], head applications engineer and director of training of the Lincoln Electric Co., Cleveland, Ohio. He used as his subject "Submerged Arc Welding." He covered some of the recent developments in automatic and semiautomatic welding. His talk was very interesting and educational. His talks are of the highest caliber in the field.

The after-dinner talk was presented by Ellis Root, manager, Cleveland office, J. E. Greiner Co. He used as his subject "The Ohio Turnpike" which was full of information and important facts of the turnpike. It was very interesting.

QUIZ PROGRAM

On March 16th twelve members and a team of experts from the *Michiana* Section accepted an invitation of the Anthony Wayne Section to attend and participate in a quiz program. A complete report on this event is given in the Anthony Wayne Section writeup at the beginning of this Section News.

HARD-FACING MATERIALS

South Bend, Ind.—The *Michiana* Section held its regular monthly dinner meeting on February 16th at Russ Restaurant. After a wonderful meal, prepared and served by Russ' personnel, the small but eager number of members present sat back for a very enlightening and informative talk by R. P. Culbertson [illegible], of the Haynes Stellite Co., Indiana, on the use of hard-facing materials being offered today in industry. Icy winds and bad weather prevented more members from attending this interesting lecture.

WELDING OF DISSIMILAR METALS

New York, N. Y.—"Welding of Dissimilar Metals" was the subject of a paper presented by K. M. Spicer [illegible], research welding engineer for the International Nickel Co., New York, at the *New York* Section meeting held on March 13th at Schwartz Restaurant.

Mr. Spicer, who has an extensive technical and practical background, gave a very comprehensive discussion of the techniques that have to be used in this process, being fully aware of the many problems which have to be considered. Mr. Spicer gave a broad outline of the compatible metals, such as Monel and nickel, as well as partly compatible and noncompatible metals, and the type of filler metal that had to be used in the various processes.

Regarding filler metals, the Schaeffler Diagram was explained, a diagram that is used and has been developed to select the proper filler material.

The importance of procedure and welder qualifications were also explained, as well as the test procedures to which specimens undergoing test have to be subjected. A number of slides were shown in the course of the talk which greatly aided in giving the audience a very good understanding of the processes.

The presentation by Mr. Spicer was excellent and the attendance was good.

WELDING IN EUROPE

Niagara Falls, N. Y.—75 members and guests of the *Niagara Frontier* Section attended dinner and 90 were present at the meeting which followed on March 22nd to hear Clarence E. Jackson [illegible], director of District No. 3, and research metallurgist in the Metals Research Laboratories.

Mr. Jackson discussed, in an interesting travelogue fashion, accompanied by colored slides, the processes and methods of welding used in foreign countries. New developments in the field of welding were reviewed and the experiences of the OEEC Mission that visited over 40 welding plants in 11 European countries were covered. The colored slides of European welding applications and of European scenic views were most excellent.

ARC WELDING

Buffalo, N. Y.—95 members and guests attended the meeting of the *Niagara Frontier* Section held on February 23rd at Mann's Three Hundred Club in Buffalo.

Speaker of the evening was Harry J. Bichsel [illegible], manager, Special Products Section, Welding Engineering Department of the Westinghouse Electric Manufacturing Corp., Buffalo. Mr. Bichsel spoke on the comparison costs of E6020 type of electrode vs. iron-powder types and also compared costs of these electrodes with metal inert-gas and submerged arc welding.

The speaker discussed the power supply, i.e., the various types of arc-welding machines available for these processes, together with slides showing features of these machines. Also discussed were certain types of inert-gas welding equipment.

PLANT TOUR

Findlay, Ohio—Some 111 members and guests of the *North Central Ohio* Section enjoyed a smörgåsbord dinner at Findlay's Country Club on March 2nd, followed by a tour of the Findlay Division of Gar Wood Industries.

Colonel G. M. Taylor, general manager of the Findlay Division gave a brief history of Gar Wood Industries and reviewed the products of the Findlay Division.

The group was guided through the factory and shown all phases of manufacturing of Buckeye ditchers, Gar Wood shovels and various other pieces of heavy construction equipment. Also included was a showing of the largest ditcher ever manufactured.

The visitors were impressed with this unusually clean and up-to-date plant. After the tour, members and guests were welcomed at the open-house celebration of the adjacent and brand new Burdette Oxygen Co.'s Findlay oxygen plant.

RECTIFIER WELDERS

Oak Ridge, Tenn.—G. K. Willecke [illegible], physicist for the Miller Electric Manufacturing Co., of Appleton, Wis., was the guest speaker at the dinner meeting of the *North East Tennessee* Section held on February 20th, at the Waldorf Restaurant.

Mr. Willecke gave an excellent talk on the use of d-c welding power supply using metallic rectifiers. His semi-technical discussion began with basic principles of welding, and theorizing the application of electrical power for welding purposes. Dr. Willecke then described the development of the metallic-rectifier-type welding machine, including the various types of rectifiers and the limitations of each unit.

Sylvania has the complete line!

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4

Tungsten Electrodes for any inert-gas welding job...

- *2% Thoriated*
- *1% Thoriated*
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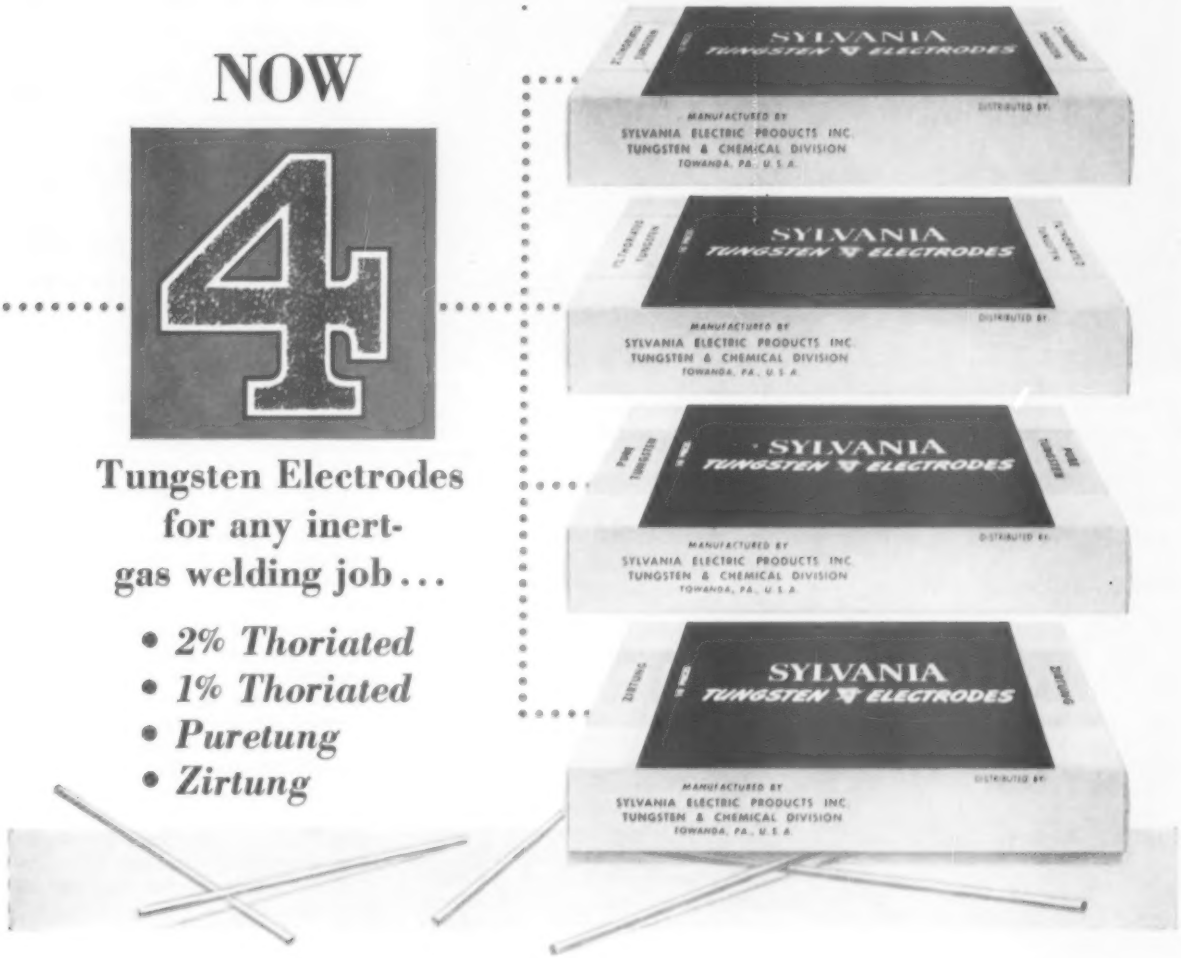

In a welding electrode, you look for dependable performance, ease of handling, economy . . . and that is why Sylvania makes four tungsten electrodes. You get all of these benefits when you use the right rod for the job.

Whether you use atomic hydrogen, helium or argon in your arc welding . . . you'll find that one of the four dependable Sylvania tungsten electrodes will give you sound, clean welds. Each of these four top-quality electrodes is manufactured to exacting specifications to assure the uniform, stable arc you need for successful inert-gas welding. Each is designed to give you the utmost in economy; minimum tungsten loss in the arc.

Sylvania Tungsten Electrodes are supplied either with chemically cleaned, etched surface or centerless ground finish. Order them in handy packages of ten from your welding supplies distributor. For technical information write to:

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NORTHWEST SECTION VISITS MARQUETTE PLANT

Members of the Northwest Section watch an extruding machine forcing the coating on welding rod at a plant tour at the Marquette Manufacturing Co. in Minneapolis, on Monday, March 12th. Left to right are Earl S. Osburn of Marquette, David E. Dallman, Norman C. Qualey, C. M. Clogston, Northwest Section chairman, and Marcus Maynard.

WELD METAL FLAWS

Erie, Pa.—"Causes and Evaluation of Weld Metal Flaws" was the subject of a talk given by R. P. Sopher [illegible], of the Battelle Memorial Institute, at the February 28th meeting of the *Northwestern Pennsylvania* Section held at the General Electric Community Center.

PLANT TOUR

Bradford, Pa.—The *Olean-Bradford* Section held its first meeting of 1956 at the Valley Hunt Club in Bradford on February 21st. After dinner, the members went on a conducted tour through the plant of Dresser Manufacturing Division of Dresser Industries, Inc. Flash, submerged arc and hand welding are extensively used in the manufacture of their products. After the tour a general discussion was held regarding the processes observed throughout the tour.

WELDING METALLURGY

Olean, N. Y.—The March meeting of the *Olean-Bradford* Section was held at the Castle Restaurant, Olean, N. Y., on Tuesday, March 20th.

Clarence E. Jackson [illegible], district director for District No. 3, North Central, gave a short address before the Section making particular reference to the forthcoming Spring Meeting and Welding Show to be held in Buffalo during May.

G. E. Claussen [illegible], metallurgist, Metals Research Laboratories, Linde Air Products Co., Niagara Falls, presented a talk on "Welding Metallurgy." Amply supplementing his talk with a series of excellent and explanatory slides, Dr. Claussen showed that metallurgy is a fundamental part of, and indispensable to, an understanding and successful application of welding. Developing this theme, Dr. Claussen discussed the basic metallurgical changes occurring in steel during heating, solidification and cooling, together with the chemical reactions which may occur; he pointed out the influence of these effects on welding and how they may give rise to such troubles as porosity, cracking and inclusions. It was explained how an understanding of the possible causes of such defects enables appropriate action to be taken to prevent them. Various metallurgical terms and diagrams, the iron-carbon diagram, *S*-curves or isothermal equilibrium diagrams, solubility curves were described in such a way that their importance and the applicability of the diagrams to welding were immediately made apparent. Many questions were provoked by the talk and much discussion ensued which was ably handled by the speaker.

The Section is indebted to Dr. Claussen for the competent way in which he presented some of the complex metallurgical phenomena related to welding, making it simple and easy to understand their significance. The meeting closed with the Section members expressing the hope that Dr. Claussen would return and address them again.

DESIGNING FOR WELDING

Peoria, Ill.—The March 21st meeting of the *Peoria* Section was held at

DRESSER PLANT VISITED BY OLEAN-BRADFORD SECTION

The February 21st meeting of the Olean-Bradford Section was devoted principally to a tour of the Dresser Manufacturing Division Plant. Shown above is the participating group

One of the principal points of attraction was the display of the various items made at Dresser

the Mecca Supper Club in Peoria with 54 members and guests present.

Omer Blodgett [AWS], of the Application Engineering Department, Lincoln Electric Co., Cleveland, Ohio, was guest speaker. His subject was: "Designing for Arc Welding."

Mr. Blodgett's talk was accompanied by slides illustrating bending, stiffness, strength and torsion. Also, he stressed the importance of diagonal bracing as a means of obtaining added strength and reduction of weight.

WELDED STRUCTURES

Pittsburgh, Pa.—A joint meeting of the AWS *Pittsburgh* Section, the Pittsburgh Section of the American Society of Civil Engineers and the Civil Section of the Engineers Society of Western Pennsylvania was held on Wednesday evening, March 21st. Two speakers were scheduled.

LaMotte Grover [AWS], consulting engineer, Air Reduction Sales Co., New York, spoke on the "Importance of Correct Details and Joint Design in Welded Structures." Van Rensselaer P. Saxe [AWS], consulting engineer of Baltimore, Md., spoke on the subject "Welded Structures." Considerable discussion followed the presentation. A large number of slides were used to illustrate these discussions.

A demonstration by the Lincoln Electric Co. on the "Simplicity of Welding" was described by C. W. Lytton [AWS].

Some 160 members and guests were present at the meeting; 65 were at the dinner which was held at the Webster Hall Hotel preceding the meeting.

FIXTURES AND PROCEDURES

Portland, Ore.—The March 6th meeting of the *Portland* Section was held at the Heathman Hotel. A social period and dinner preceded the meeting.

Speaker of the evening was Byron R. Russell [AWS], owner, Airline Welding and Engineering Co., Hawthorne, Calif. His talk, "Automatic Fixtures and Procedures for Fusion Welding of Missiles and Commercial Applications," was of great interest to all. It covered design, fabrication and weld testing of fixtures used to produce fusion welded parts. These include fixtures used in production of jettisonable fuel tanks and napalm bombs. Tungsten-arc, shielded-gas metal-arc, and automatic submerged-arc welding were all reviewed. The talk was elucidated with slides and motion pictures and samples of welded titanium were made available to all present. Mr. Russell gave interesting information on "cold working" of metals and he presented facts obtained on process equipment developed by his firm.

MAINTENANCE WELDING

Richmond, Va.—"Improved Maintenance Welding Techniques" was the subject of an excellent talk given by L. D. Richardson [AWS], of the Eutectic Welding Alloys Co., at the March 16th dinner meeting of the *Richmond* Section held at the Hallo-way House.

Mr. Richardson's talk accompanied by slides, traced the early history of welding and discussed the problems and techniques encountered in maintenance welding. He pointed out the vastly different problems of production and maintenance welding. He described the various repairs which were being accomplished by using low-melting-point materials.

ACTIVATION MEETING

Sacramento, Calif.—An activation meeting was held on March 1st at the Capitol Inn in Sacramento with 57 in attendance, including the chairmen of the *San Francisco* and *Santa Clara Valley* Sections, Second Vice-President C. P. Sander and Director-at-Large Ray Townsend.

It was the consensus of the people present that an AWS Section was needed in Sacramento; therefore, a committee was appointed to function as an organization group for setting up programs for the next few months.

Guest speaker at this meeting was J. E. (Ed) Dato [AWS], of the Linde Air Products Co., New York, whose subject was "Inert-Gas Welding and Cutting."

ASPECTS OF WELDING

Saginaw Valley, Mich.—Some 140 members and guests were present at a joint meeting of the *Saginaw Valley* Section and the American Society for Metals, held on March 15th at the High Life Inn. This joint meeting resulted in an exceptionally large group and was a great success.

Technical speaker was W. S. Pellini [AWS], superintendent of Metallurgy Division, Naval Research Laboratory, Washington, D. C.

Mr. Pellini's talk on "Aspects of Welding Metallurgy" was delivered in a very interesting and informative manner. Many guests stayed and talked with Mr. Pellini and many questions were asked at this lively discussion.

WELDING OF ALUMINUM

St. Louis, Mo.—The early history of aluminum and its progress up to the present time was discussed by William B. Rogerson, assistant chief of Welding Section, Aluminum Company of America, at the March 9th dinner meeting of the *St. Louis* Section held at the Unique Restaurant. Mr. Rogerson traced the evolution of methods of joining aluminum; the latest techniques and procedures of welding and brazing the common and new aluminum alloys. The talk was well illustrated by slides and movies.

WELDING ALLOY STEELS

San Francisco, Calif.—The *San Francisco* Section met on March 26th and heard Bernard Faas [AWS], Welding Engineer, Standard Oil Co. of Calif., discuss welding done in the construction and maintenance of refinery equipment.

Mr. Faas pointed out that the high cycling temperature, high pressures and corroding tendency of the stock make good welding a necessity to protect plant and plant personnel. The basic standards which govern weld quality are reliability, safety and economy.

Welders are qualified by a standard pipe test. Welds are checked by guided bend, nick and break and ductility tests.

In welding alloys, two principles are maintained: (1) the electrode must at least match the base metal in alloy content; (2) the weld and heat-affected zone must have the best practicable ductility. The latter is improved by heat treatment.

Among the alloy steels are those with chromium ranging to 9% and molybdenum to 1%, with the carbon held to 0.15% max. These steels are welded with low-hydrogen electrodes; they are preheated to 400–600° F and maintained at 1200–1350° F. This treatment also softens the heat-affected zone, increasing ductility and eliminating metallurgical notches.

Austenitic stainless rods may be used, but higher expansion of the weld metal is a disadvantage in cyclic operations.

Mr. Faas also explained that failures of weldments in service are usually the result of stress cracking or stress-corrosion cracking. The latter results from high stresses working in conjunction with the corroding stock. Identification of the specific cause of failure is often possible, and means can then be taken to offset the conditions causing failure.

The extra-low-carbon stainless

A Report on Automatic Arc Welding

A G-E WELDING ENGINEER EXPLAINS ARE TURNING MORE AND MORE TO

Roger W. Tuthill, Welding Process Engineer for the General Electric Company's Welding Department, answers some of the more frequently asked questions about the gas-shielded, consumable-electrode welding process.

Mr. Tuthill's answers explain the increased attention this process is receiving from production and welding people as automation begins to make greater demands on production welding.

Mr. Tuthill has been active in research and development on Fillerarc welding, General Electric's gas-shielded process, and has had a number of papers published on the subject.

Q. What is the gas-shielded welding process?

A. Gas-shielded welding is a consumable-electrode arc welding process which uses a reel of bare electrode wire fed mechanically through a welding head. Gas, such as carbon dioxide or argon, flows around the electrode to form a protective shield about the arc.

Q. Is there anything particularly new about gas-shielded arc welding?

A. Yes—if you're talking about ***automatic*** gas-shielded arc welding!

Historically, powdered flux has been used as the shielding agent in automatic arc welding, mainly because no gas process was economically feasible for welding mild steel. However, gas-shielding was attractive to many prospective users because it eliminated the many problems created by the use of flux—expensive flux recovery systems, flux inclusions in welds, flux in the air, more precise fixture requirements, and other difficulties.

Gas-shielding has been used for welding non-ferrous and stainless steels, but the relatively high costs of the inert gases used made gas-shielding impractical for mild steels.

Recently, the successful application of low-cost carbon dioxide as a shielding gas has finally made it economical to use gas-shielded equipment for welding mild steels. For example gas savings of 90% over inert gas costs have been reported. Since by far the most welding being done today is on mild steel, it is easy to see why this development is causing so many production people to turn to automatic gas-shielded arc-welding for answers to their production welding problems.

Q. Does a gas-shielded automatic welding system cost any more than other automatic arc welding systems?

A. The cost of setting up a gas-shielded system is about the same as for a comparable submerged-arc automatic system.

For example, while the ***purchase*** price of gas-shielded automatic equipment may be more than that of a submerged-arc system, the fact that there is no need for installing expensive flux recovery equipment and other cleaning systems with gas-shielded welding easily makes up the purchase price difference.

Q. Does the quality of welding done with gas-shielding compare with other welding processes?

A. Quality of welds made with the gas-shielded automatic welding process compares very favorably with other processes. Since no flux is used there is no possibility of flux inclusions; penetration is usually deeper; and the visible arc permits full control during welding. This visible arc permits less expensive fixtures to be used, an important cost factor in automatic welding.

Q. How about the speed and flexibility of a gas-shielded system? Can it be easily integrated into a production line?

A. A gas-shielded system can be used in production line welding as easily as any automatic welding system.

For example, the G-E Fillerarc system has electrode wire feed speeds which range up to 1000 inches per minute.

WHY FABRICATORS OF MILD STEEL AUTOMATIC GAS-SHIELDED WELDING

The automatic head can be rotated through 360 degrees and can be used for circular or seam welds, and, if necessary, more than one welding head can be used to make multiple welds.

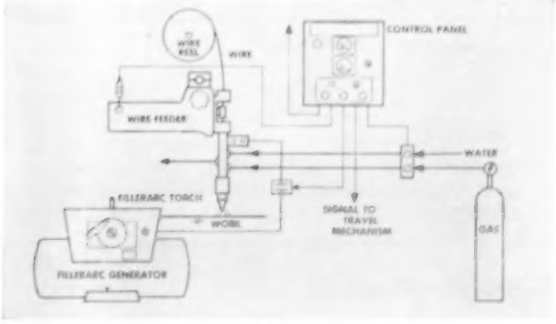
These characteristics make the Fillerarc system flexible and fast enough for almost any production line. Perhaps of equal importance to production people is the system's insensitivity to incoming line voltage, which assures constant production speed and weld quality.

Q. To sum up, what are the really important advantages of the automatic gas-shielded welding process?

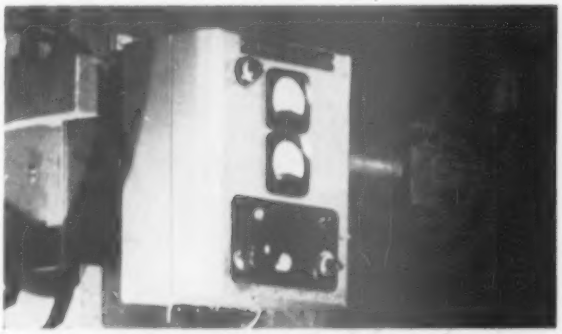
A. In a few words, the most important advantages of the automatic gas-shielded process are flexibility, high welding speeds, uniform weld quality, elimination of the cleaning problems associated with the use of flux, versatility for use with all types of metals, and most important of all, the ability to use low-cost carbon dioxide for shielding.

For more information about Fillerarc automatic gas-shielded welding see your nearby G-E Welding Distributor, or write for Bulletin GEC-1334, Section 713-4, General Electric Company, Schenectady, N. Y.

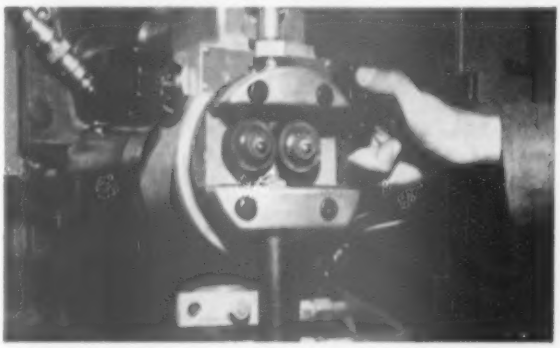
See G-E Fillerarc automatic welding equipment demonstrated at the American Welding Society Convention, Buffalo, N. Y., May 9–11. Booth numbers 47, 48, 49.



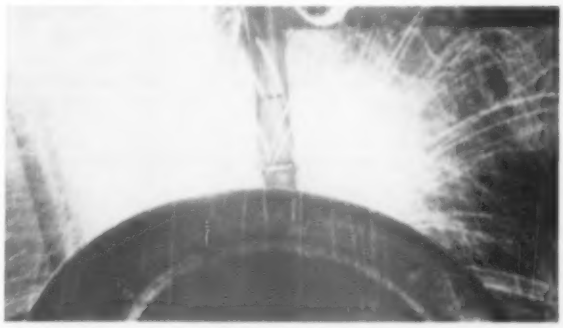
G-E FILLERARC EQUIPMENT is the only complete equipment especially designed for consumable-electrode, gas-shielded welding. Simplicity of the system makes possible use of less expensive fixtures and greater over-all efficiency.



WIDE RANGE OF WIRE-FEED SPEEDS—up to 1000 inches per minute—makes the G-E Fillerarc system flexible enough for any production line. Speed is constant since system is insensitive to normal line-voltage changes.



FLEXIBILITY OF FILLERARC SYSTEM is also demonstrated by the automatic head. It rotates 360 degrees, allowing even overhead welding. Arc is completely visible since gas is used as the shield instead of flux.



CIRCULAR OR SEAM WELDS may be made on stainless steel, copper, aluminum, and other metals—using inert gas. Fillerarc power sources, rectifier or motor-generator, and carbon dioxide combine for low-cost, quality welds on mild steel.

Progress Is Our Most Important Product

GENERAL ELECTRIC

3 NEW G-E Power Sources for Automatic Welding

Now, three new General Electric 800-amp rectifier welders join the already-proved Fillerarc 450-amp motor-generator set as power sources for the expanding gas-shielded automatic welding process.

The three new power sources are designated FILLERARC, REGULARC, and DIRECTARC and offer a complete choice of output characteristics and automatic features. (See comparison chart below.)

FILLERARC—gives you the ideal power source for automatic gas-shielded welding. Like the 450-amp Fillerarc motor-generator, this rectifier welder has a unique rising volt-ampere characteristic which automatically matches the arc requirements for all electrode wire feed speeds. It is immune to changes in incoming line voltage, thus assuring consistent weld quality.

REGULARC—The first *true* constant-potential power source offered for automatic welding, this welder provides all the features of the Fillerarc model except that it has a flat volt-ampere characteristic. This is the set for you if your application requires regulation of incoming line voltage and only relatively small changes in electrode wire feed speeds.

DIRECTARC—With minimum investment, Directarc offers the same high quality design and construction of the other models without the automatic features. Directarc is the choice for you if you have a well-regulated incoming line voltage and your application requires only one arc length and electrode wire-feed speed.

QUALITY RECTIFIER FEATURES—All three models offer the same high quality you've come to expect in G-E rectifier welders—quiet operation, combination cleaning-cooling fan, easily removable side covers, and Class H silicone insulation.

For more information see your nearby G-E Welding Distributor (He's listed in the yellow pages of your phone book) or write Section 713-5, General Electric Company, Schenectady 5, N. Y.

Power Source	Output Volt-ampere curve	Immune to Incoming Line Voltage Change	Adjustable Starting Voltage	No Change in Arc Length with Change in Electrode Wire Feed Speed
FILLERARC	Rising	Yes	Yes	Yes
REGULARC	Flat	Yes	Yes	No
DIRECTARC	Essentially Flat	No	No	No

Progress Is Our Most Important Product

GENERAL ELECTRIC

steels are finding greater use in refinery service because of the difficulty of properly stress relieving stainless welds.

The meeting at Plands Restaurant, Oakland, Calif., was enjoyed by some 90 members and guests.

WELDING AND CUTTING ALUMINUM

San Francisco, Calif.—The *San Francisco* Section held its February meeting on the 20th in the Plands Restaurant, Oakland, where G. O. Hoglund [M2], head of the Welding Section, Alcoa Process Development Laboratory, spoke on "Developments in Welding and Cutting Aluminum."

Most of the developments in welding, according to Mr. Hoglund, have occurred in arc welding and vessels with walls to 6 in. thick are now being welded. Advantage is now being taken of welding to fabricate equipment in which weight-saving, electrical conductions, nonmagnetic properties, chemical properties or corrosion resistance is desired.

The magnesium-bearing alloys such as 5356 have excellent weldability. The 6061 alloys, although weldable, may require reheat-treatment.

Tests of welded 5151-H 36, 6061-T6 and 3003F indicate that fatigue strength is a function of cycles and not alloys. These same alloys have excellent ductility at −280° F; in some cases they are almost as good as at room temperature. They exhibit no transition temperatures.

The electric arc in combination with a shielding atmosphere is used to cut aluminum and other alloys by the melting process. In principle, the energy of the arc and gas stream melts and mechanically removes the molten metal to form a kerf while the protective atmosphere prevents oxidization.

Eighty-five members and guests enjoyed Mr. Hoglund's instructive lecture.

MAINTENANCE WELDING

Sangamon, Ill.—The *Sangamon Valley* Section held a dinner meeting on March 13th at The Mill.

Technical speaker was D. L. Caldwell of the Caterpillar Tractor Co., Peoria. Mr. Caldwell spoke on "Maintenance and Welding Circuit Maintenance."

ARC WELDING AND CUTTING

San Jose, Calif.—J. E. Dato [M2], assistant manager, Welding, Linde Air Products Co., New York, was the speaker at the February 28th dinner meeting of the *Santa Clara* Valley Section. 95 members and guests were present to hear an excellent discussion on "Inert-Gas Welding and Cutting" as presented by Mr. Dato. Slides showing the new aluminum cutting processes and samples cut by this process were shown in addition to slides of inert-gas welding procedures and processes.

RECTIFIER WELDERS

Shreveport, La.—The February dinner meeting of the *Shreveport* Section was held on February 16th at the Caddo Hotel.

Speaker for the evening was G. K. Willecke [M2], of the Miller Electric Manufacturing Co., Appleton, Wis.

Dr. Willecke gave a brief account of the electric arc, stating that it represents a high concentration of energy. When welding, this energy is concentrated at the weld zone.

The speaker explained the fundamental principle of motor-generator, a-c and rectifier-type welding machines. He briefly explained the various types of tube and metallic rectifiers and how they operate. The rectifier was described as an electrical check valve which will allow current to flow in one direction only.

Of the presently known rectifiers, the selenium rectifier is best suited for welding machines from the standpoint of amount of current passed for a given size, voltage it will withstand, and ruggedness.

Dr. Willecke also described how a selenium rectifier is made. It consists of aluminum support plates, with 0.002-in. thick layer of selenium deposited on the surface of the plate. The plate is then heat treated to get the selenium in crystalline form. Next, an alloy having a melting point slightly lower than selenium is sprayed over the selenium. The alloy coating on front of plate is known as front electrode. The barrier layer between selenium and front electrode is where current is rectified. The ratio of current passing through the barrier layer in one direction, as compared to opposite direction, is as high as a million to one.

WELDING CODES

Shreveport, La.—A very fine dinner meeting of the *Shreveport* Section was held on March 16th at the Caddo Hotel. Coffee speaker was J. G. Magrath, national secretary, who gave an informative talk on the SOCIETY—its reason for being, how it was organized, what it is, and what it does. He pointed out that it is the membership which makes it a "national" SOCIETY. It is an engineering, edu-

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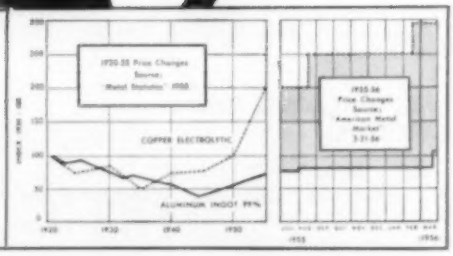

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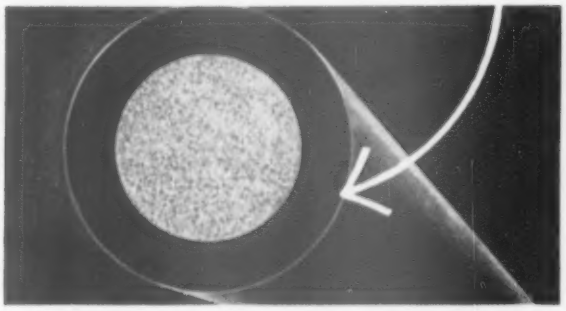
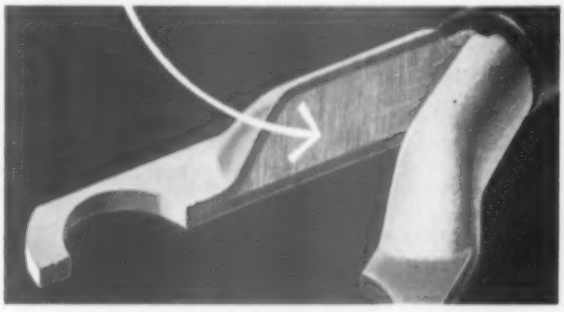
the weight of copper cable—plus other important benefits!

2 EXTREMELY FLEXIBLE to make work easier! The fine wires used for aluminum welding cable assure *maximum* flexibility, plus toughness and durability. Aluminum welding cable can easily be looped into a circle with thumb and forefinger—demonstrating the freedom of movement it provides to the welder.



3 DURABLE to withstand hard use! Tough rubber jacket resists abrasion, acids, sunlight and heat. For extremely hard usage, a neoprene jacket is available which offers maximum resistance to abrasion, acids, alkalies, grease, oil, sunlight and heat. In addition, the neoprene jacket is flame-resistant.

4 COOLER to make handling more comfortable! Aluminum welding cable dissipates heat almost twice as fast as copper cable of similar size. As a result, the aluminum cable and electrode holder is far cooler and more comfortable to handle.



5 EASY TO SOLDER for tight copper or brass terminals! Terminal lugs or accessories can be soldered to aluminum welding cable by a simple 4-step method: 1) heat socket or lug barrel with small torch flame, 2) apply non-zinc chloride type flux inside barrel, 3) insert soldering wire while applying heat, and fill ⅔ full, 4) gently work stripped end of cable into solder socket, remove flame, and allow to cool. Connection is then ready for use. Aluminum welding cable also takes good mechanical connections.

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* * *

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cational and service organization with activities of a scale making it larger than many well-known industrial organizations. Industry supplies well over 600 engineering specialists who work on the SOCIETY's many committees, formulating its codes, standards and specifications which are utilized by industry for producing better welded products. These men are the best available. The text in THE WELDING JOURNAL is contributed by the most learned industrial welding and engineering minds in the world.

Mr. Magrath explained the manner of the organization of the SOCIETY's Board of Directors and its Standing and Technical Committees, as well as how the SOCIETY coordinates its activities with more than twenty-five technical and engineering organizations in this country and with those in eleven foreign countries. He pointed out the need of keeping abreast of developments in foreign lands as, while the United States is far advanced in production, there are instances where, in some fields, some foreign groups are technologically ahead of us.

The technical speaker of the evening, B. C. Doggett of the J. B. Beaird Co., discussed the more familiar codes and specifications. He explained how these codes apply to builders and fabricators in the pipe, vessel, structures and transportation fields. These codes and specifications are not within themselves mandatory; they are often made so by customers and local ordinances.

Mr. Doggett gave the following three reasons as to why codes exist:

(1) Safety—life and property
(2) Uniformity of thought
(3) It is the one way that information resulting from a great deal of thought and experimentation is made available and utilized

Customers use codes as guide in getting what they want, although they may add special requirements.

A question-and-answer period followed with Mr. Doggett and his panel of experts answering the questions put to them.

POSITIONING

Miami, Fla.—Guest of honor at the March 21st meeting of the *South Florida* Section was AWS President J. H. Humberstone who gave a very interesting and educational talk on the SOCIETY's activities, the functioning of the various Directors, the revising of the WELDING HANDBOOK and other important matters. Mr. Humberstone's comments were most helpful to those present.

The guest technical speaker of the evening was Jack Jarms [AWS], of the P. & H. Corp. in Milwaukee. Mr. Jarms gave a very interesting talk on "Positioners."

The meeting was held at the Republican Club and the dinner at Harts Restaurant.

TOLEDO SECTION HOST TO HUMBERSTONE, STITT AND CARNEY

This group picture was taken at the February 21st meeting of the Toledo Section. *(Left to right)* J. L. Barker, Sun Oil Co.; Ray Stitt, AWS district director; J. L. Carney, technical speaker for the evening; J. H. Humberstone, AWS president; and L. H. Shanteau, Toledo Section chairman

President Humberstone extends his congratulations to the officers of the Toledo Section. *(Left to right)* S. Snell, treasurer; R. Hoefler, secretary, Mr. Humberstone, W. Schmidt, first vice-chairman, T. Ellis, second vice-chairman and Chairman Shanteau

ALLOY PIPE WELDING

Toledo, Ohio.—The February 21st meeting of the *Toledo* Section was the largest ever held by this Section with an attendance of 122.

Some 55 men attended the dinner. The Section was honored to have as coffee speakers AWS President J. H. Humberstone and Ray Stitt, District Director. Mr. Humberstone spoke briefly on the aims of the SOCIETY and the advantages of a Company Membership. Following Mr. Humberstone's fine talk, Mr. Stitt discussed individual memberships and also congratulated the Section on their past membership work and suggested they take advantage of the large turnout to increase membership for this year.

The technical speaker was J. E. Carney [AWS], chief metallurgical engineer for the Sun Oil Co. Mr. Carney gave an excellent talk on problems encountered in alloy pipe welding for high-temperature service. He discussed the results of research on different welding processes to assure complete, crack-free, root passes and the advantages and disadvantages of different techniques. He also covered very thoroughly the method of determining the proper preheat and postheat temperatures of the low-chrome alloys and pointed out the importance of preheat and postheat of these alloys.

Following his talk, Mr. Carney answered a number of questions from the floor, most of these covering the

selection of electrode for welding these low-chrome alloys. At all times Mr. Carney was definite in his answers and in his statements; this impressed those present very favorably.

INERT-ARC WELDING

Toledo, Ohio—The March meeting of the *Toledo* Section was held at the Maumee River Yacht Club, on Tuesday, March 20th. The main speaker was J. R. Larimer (AWS), service engineer for the Detroit Division of the Linde Air Products Co., who spoke on "Inert-Arc Welding and Brazing." Mr. Larimer's talk covered gas tungsten-arc and gas metal-arc welding of plate and pipe. He discussed butt, fillet, spot welding and inert-arc cutting of hard-to-cut metals. His talk was illustrated with very interesting slides. Mr. Larimer's presentation was followed by a lengthy question-and-answer period, during which many interesting problems and applications were discussed.

NONDESTRUCTIVE TESTING

Sheffield, Ala.—Robert G. Strother of the Magnaflux Corp. was the speaker at the February 16th meeting of the *Tri-Cities* Section held in the T.V.A. Auditorium. Mr. Strother spoke on "Nondestructive Testing of Weldments."

GAS SHIELDED WELDING

Worcester, Mass.—J. D. Carey (AWS), of the Welding Processes Division of the General Electric Co., York, Pa., was the speaker at the March 5th dinner meeting of the *Worcester* Section held at the Hickory House.

Mr. Carey's address covered a description and brief history of the "Consumable-Electrode Gas-Shielded Welding Process," using gases such as helium and argon.

He cited as advantages: (1) the absence of a flux; (2) high travel speeds; (3) joints are easily seen and can be followed; (4) electrodes are continuous, with many feet on each reel; (5) less operator skill is required; and (6) the process is ideal for automation.

With regard to the use of CO_2 for welding mild steel, Mr. Carey described the unusual arcing characteristics, the disassociation of carbon dioxide in the arc, the recombining of carbon and oxygen outside the arc, the deep penetrating type of weld, good weldability of mild steel, the difference in edge preparation, as compared with that required for the inert gases, and the excellent mechanical properties of the weld deposit.

Using slides, Mr. Carey showed the results obtained with electrodes of various analysis when using helium, argon, and CO_2. His tests have proved that very satisfactory welds can be made with CO_2 on various applications.

Mr. Carey pointed out that preheat may still be required for higher-carbon steels. He warned that this welding method requires a CO_2 gas with a very low-moisture content; otherwise, porosity shows up in the welds. Also, there is more weld spatter with CO_2 than with argon.

Following the guest speaker's talk, a highly recommended high-speed movie was presented which showed the metal transfer across the arc, using aluminum, copper, stainless steel, magnesium, and mild-steel electrodes. Helium, argon, argon-oxygen and 100% carbon dioxide shielding gases were used.

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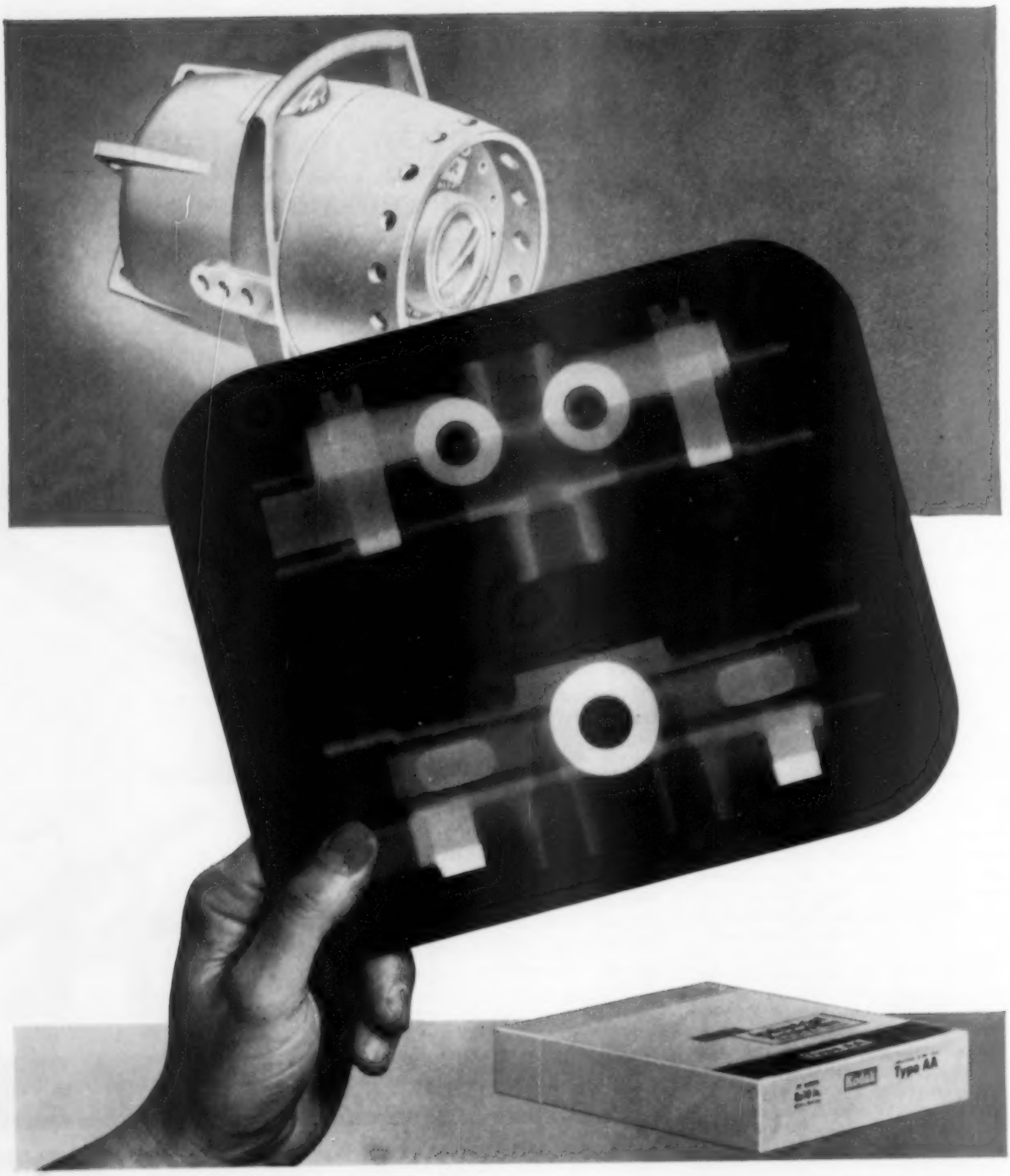

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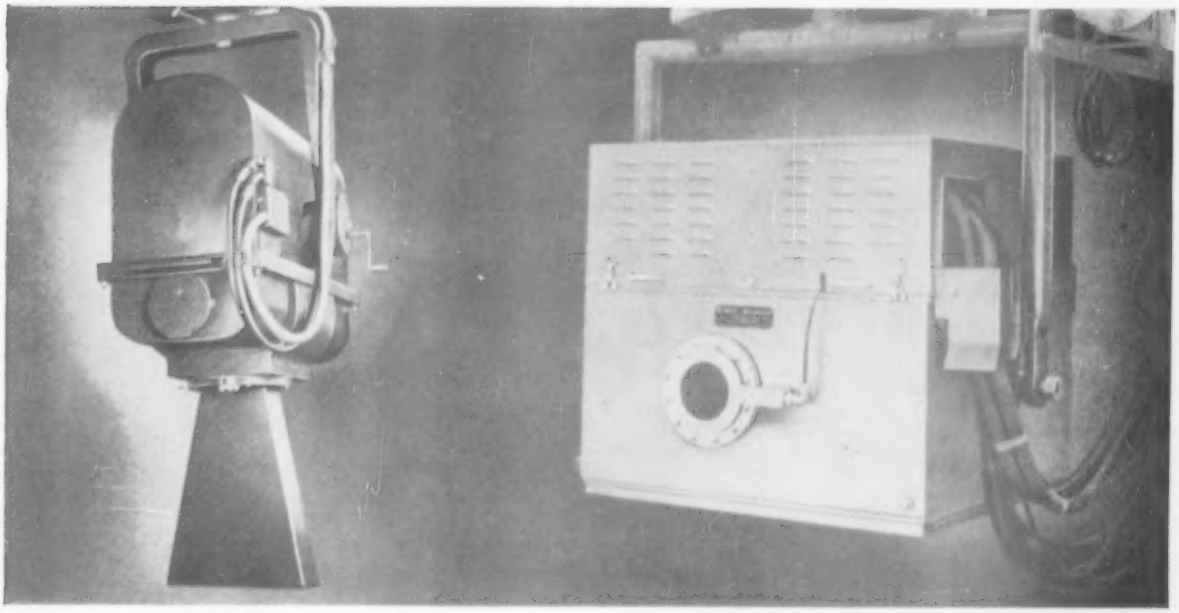

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Total National Membership March 1, 1956

Sustaining Members	*127*
Members	*5,435*
Associate Members	*5,746*
Student Members	*212*
Honorary Members	*9*
Life Members	*16*
Total	**11,545**

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Gilliard, Jack (B)
Snyder, T. J. (C)

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Fryatt, William H. (B)
Gilpatric, George A. (B)
Lehman, Regis (C)
Norman, Wilfred J. (C)

BRIDGEPORT

Smith, Thomas G. (B)

CHICAGO

Evins, I. J. (B)
Garrett, Martin A. (B)
Hoeller, Robert L. (B)
Isaachen, John G. (C)
Kavis, Theodore (B)
Kerber, Robert G. (C)
Pizzato, Alfred A. (B)

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Miller, Pierce J. (C)
Shapter, D. E. (C)

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Grey, Gregory F. (A)
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Scott, Edward T., Jr. (C)
Thompson, J. N. (B)
William, Robert N. (B)
Zagore, Frank J. (C)

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Vowell, Ray D. (B)
Young, Edward M. (C)

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Knipp, John L. (B)
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Pattee, Harry E. (C)

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Bellows, Harry (C)
Chopko, Alex T. (B)
Crisenbery, Donald B. (C)
Des Roches, Henry (C)
Gongla, Theodore T. (B)
Hardy, William (B)
Jordan, Joseph (B)
Koska, John (B)
Krotzer, Duran A. (B)
Langevin, Raymond E. (B)
Ludwig, William (C)
McCall, William A. (B)
McGuire, John L. (B)
Paputa, Rudy (B)
Peirce, H. D. (B)
Runde, Byron (B)
Willman, Walter O. (B)

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Van-Der-Wielen, Dom. (C)

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Foreman, James C. (B)
Hilderbrand, Edward L. (C)
Miller, John R. (B)
O'Brien, J. T. (B)
Patterson, Dean E. (B)
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Valentine, Jack M. (B)
Warnke, O. B. (B)

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IOWA

Faulkner, John M. (C)
Roush, Henry E. (B)

IOWA-ILLINOIS

Rowe, Herbert B., Sr. (C)

KANSAS CITY

Lambert, Gene (C)
MacDonald, E. F. (C)

LEHIGH VALLEY

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Laxar, Francis H. (C)
Martin, Allen (C)
Naab, Julius (B)

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Aguilar, Edward (C)
Dillard, Clifford S. (C)
Graham, Norris J. (C)
Spillman, W. J. (C)
Tribolet, Michael A. (C)

LONG ISLAND

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Quaas, Joseph F. (B)

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Barker, Tessie (C)
Beck, Lee W. (C)
Bell, Ruby, Mrs. (C)
Beneah, Joe (C)
Bier, Harold H. (D)
Bond, Frank G. (D)
Bramblett, Horace F. (C)
Brolaski, George R. (C)
Burnley, Martin F. (C)
Cambell, F. S., Jr. (D)
Cornford, W. E. (D)
Darrach, Charles G. (C)
Davis, C. P. J. (C)
Donovan, D. F. (D)
Ericsson, Earl R. (C)
Fisher, A. H. (D)
Forrest, Thomas A. (B)
Foss, Lloyd A. (C)
Hattig, Bill L. (C)
Holder, John H. (C)
Hopman, John P. (C)
Hunt, Claude G. (D)
Kapes, Helen Y. (C)
Lanaro, Einar (C)
Malock, Ranay (C)
Maynard, Herbert (C)
McBee, E. A. (C)
McDonald, A. J. (C)
McWilliams, R. T. (D)
Meredith, Russell (B)
Miles, Harold B. (D)
Nuckolls, O. W. (D)
Paradis, Oliver (D)
Shultz, Robert E. (B)
Stocks, David L. (B)
Swanston, Dale L. (C)
Vanderpool, J. W. (D)
Vidie, John R. (B)
Vivian, Robert L. (D)
Walsh, Thomas I., Jr. (D)
Welter, George Y. (D)
Yatsko, John A. (D)

LOUISVILLE

Schmitt, Robert L. (C)

MADISON

Samuelson, Theodore N. (B)
Tucker, John (B)

MARYLAND

Brodsky, Harry (C)

MICHIANA

Bloxson, Verland D. (C)

MILWAUKEE

Dombrowski, Thaddeus J. (C)
Yoder, Laurel D. (C)
Zahnzinger, Claude O., Sr. (C)

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Culton, William R. (C)
Hanighen, J. J. (B)
Lindsey, Robert E. (B)

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Blewitt, Eugene (C)
Bowden, Edward F. (C)
Hamilton, Harry P. (C)
Kerr, Kenneth H., Jr. (C)
Teague, J. H. (C)

NEW ORLEANS

Milford, Charles R. (B)
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Bayer, Alfred R. (B)
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Gasparrini, William (B)
Gordon, Emanuel (B)
Krushel, Charles (B)
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Sharpe, Joseph F. (B)
Steele, Robert D. (C)

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Stoiber, Aloysius J. (C)
Swan, Frederick W., Jr., (C)
Woodward, Robert B. (C)

NORTH CENTRAL OHIO

Clark, W. L. (B)
Ford, Ralph R. (B)
Mooney, James (C)

NORTHEAST TENNESSEE

Fulton, T. W. (B)
Fultz, James D. (C)

NORTHERN NEW YORK

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Hawthorne, J. R. (C)
Marinelli, Joseph (C)

NORTHWEST

McEvoy, John W. (B)
Von Tobel, George H. (D)

OKLAHOMA CITY

Barker, Charles H. (C)
Boden, K. B. (D)
Chalfant, G. B. (C)
Gee, John C. (B)
McDonald, John W. (D)
Taylor, Jack M. (D)
Williams, H. R. (C)
Wilson, C. E. (D)
York, Haskell (D)

OLEAN-BRADFORD

Peelman, Robert D. (B)

PHILADELPHIA

Beck, M. L. (B)
Belzer, Robert K. (B)
Bowers, Lester T. (C)
Deehar, James J. (C)
Delph, William H. (B)
Pryse, Walter W., Jr. (B)
Utter, Rodney G. (B)

PITTSBURGH

Hamilton, J. R. (B)
Maloney, John P. (B)
McNaughton, Walter K. (C)
Mears, Harry A. (B)
Speedy, Donald C. (C)

PORTLAND

Focht, Orville A. (C)

PUGET SOUND

Bartz, E. W. (B)
Butterfield, William C. (C)
Craig, Cecil M. (B)
Kiff, Kenneth L. (C)
McBride, C. M., Jr. (B)
Sawhill, Charles F. (C)
Stumpff, Donald H. (B)
Sutherland, Robert M. (B)

RICHMOND

Matt, William F. (C)
McCarthy, Carl R. (C)

SAGINAW VALLEY

Maczik, Edwin (C)
Saupe, Walter R. (D)
Wiltse, Lee (C)

ST. LOUIS

Castle, Harley W. (B)

SALT LAKE CITY

Oyster, Gerald J. (B)
Peck, E. K. (C)

SAN FRANCISCO

Zehetmir, Albert R. (B)

SANGAMON VALLEY

Barnes, George W. (C)
Schoening, H. J. (B)

SANTA CLARA VALLEY

Kirgher, Henry F. (C)
Parkman, Ralph (C)
Simon, Theodore J. (C)
Sloan, Marvin R. (B)
Trumbull, David G. (C)
Whelan, Harry G. (C)

SHREVEPORT

Edwards, M. J. (B)
Jones, Carl E. (C)

SUSQUEHANNA VALLEY

Griff, Bernard (C)

SYRACUSE

Zembek, Fred G. (C)

TOLEDO

Heizelman, John R. (C)

TRI-STATE

Ellis, Leslie (B)

WASHINGTON, D. C.

Myers, Murrel L. (C)
Parker, J. Bruce (C)
Yowell, Allen R. (C)

WICHITA

Myers, James E. (B)

NOT IN SECTIONS

Freeman, Fred E. (C)
Hart, Edwin E. (B)
Mackay, I. D. (B)
Metz, Edward R. (B)

Members Reclassification

During the Month of March

CINCINNATI

Miller, David Ray (D to C)

DALLAS

Thomas, Irvis L. (C to B)

MADISON

Brunt, James G. (D to C)

TOLEDO

Hoefler, R. H. (C to B)

YORK-CENTRAL PA.

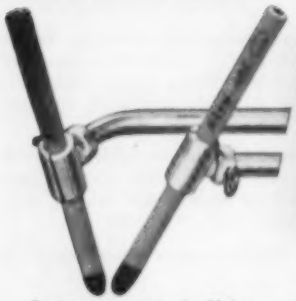
Kunez, Frank, Jr. (D to C)

NOT IN SECTIONS

Hoefer, H. W. (C to B)

BECKER

KEEN-ARC CARBONS



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Eighth Page	62.00	58.00	50.00	46.00
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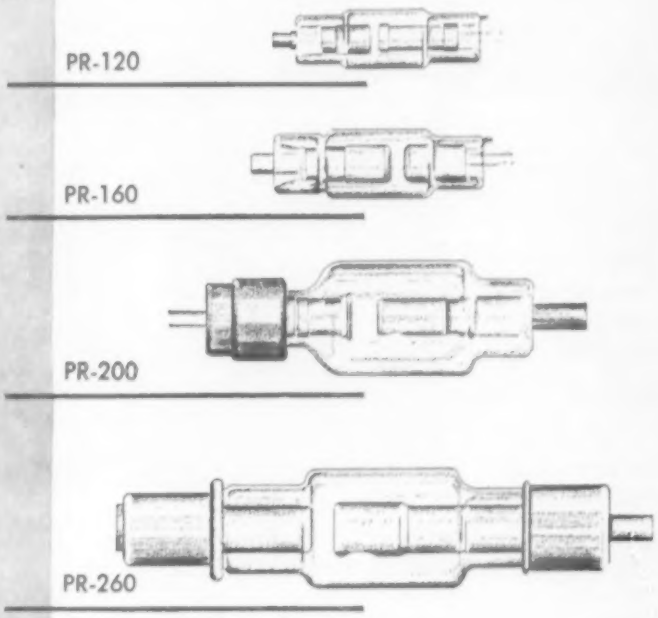

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- Equipped with small focal spot.
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PR-160	160	5	1.5
PR-200	200	5	1.5
PR-260B	260	5	2.3
PR-260C	260	10	3.5

MACHLETT

MACHLETT LABORATORIES, Inc., Springdale, Connecticut

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Half the Cost is saved in producing stator housings formerly done by manual type welding. One of many production operations where automatic welding proves profitable.

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NEWS of The Industry

1956 Annual Convention Held by IAA

The Annual Convention and Business Meeting of the International Acetylene Association was held in the Hotel Statler, Los Angeles, March 12, 13 and 14, 1956. The three-day meeting was a source of new ideas, inspiration, and entertainment to all IAA members and their friends and guests who were interested in the acetylene industry and its associated products.

Opening Luncheon Features Rocket Talk

An opening luncheon was held at noon on Monday, March 12th, in the Pacific Ballroom of the Hotel Statler. Dan A. Kimball, president of Aerojet General Corp. presented a most interesting and thought-provoking address, "Where Are We Going with Rockets." The Honorable Norris Poulson, mayor of the city of Los Angeles, said a few words of welcome.

Slottman Receives Morehead Medal for 1956

The Morehead Medal, presented annually in recognition of outstanding service or achievement in the acetylene industry, was awarded to Dr. George V. Slottman, vice-president and director of research, Air Reduction Co., Inc., New York. Addresses were presented by John R. Hoover, president, B. F. Goodrich Chemical Co., and John A. Hill, president, Air Reduction Co., Inc., C. McL. Pitts, vice-president, International Acetylene Association, and president, People's Gas Supply Co., Ltd., presided. The presentation of the medal was made by E. A. Daniels, vice-president of the Victor Equipment Co., and director and past president of the International Acetylene Association.

Technical Sessions

On Monday afternoon, there were two simultaneous sessions, one on transportation and one on petroleum. Likewise, there were two sessions on Tuesday afternoon. One of these was on welding engineering and shop operations, and the other was on special oxyacetylene applications.

Education Session

On Tuesday morning, there was a session on education. In line with the aim of the Program Committee to provide for better understanding by educators and leaders of industry of the mutual problems faced in preparing young people to take places of responsibility in industry and business, a seminar and discussion was arranged on the subject with men who are familiar with various levels of our educational system and also with the needs and opportunities in industry.

The Annual Business Meeting, for members only, was held in the Sierra Room of the Statler Hotel at 9:15 A.M., Wednesday, March 14th. The agenda included the reports of officers, committee chairmen and the consulting engineer; the election of officers for the ensuing year, and other business.

Appointments Announced by G.E.

James N. Thompson has been named manager of the General Electric Welding Department's newly created East Central District. Mr. Thompson will make his headquarters at 20810 Miles Ave. in Cleveland. The East Central District, with sales responsibility for all types of G.E. welding equipment, electrodes, and accessories, includes Ohio, Kentucky, and Indiana.

Concurrently, Mr. Thompson announced the establishment of a General Electric welding sales office and warehouse in Cleveland, to be located at the same address. He also announced the appointment of Hubert G. Hinkel as supervisor of the new sales office, and of William E. Cooper as sales engineer for the new district.

Wellman Engineering Elects New President

Robert C. McDowell has been elected president of the Wellman Engineering Co., of Cleveland, Ohio, a leading engineering and machinery fabricating firm.

Succeeding Dr. J. C. Hodge, who resigned from both the Wellman presidency and board, Mr. McDowell is also president of McDowell Co., Inc. He became chairman of the board of Wellman Engineering in 1954 when McDowell Co. acquired about 90% of the former company's outstanding stock.

Henceforth he will serve as both chairman and president of Wellman, the announcement stated.

Founded by Samuel T. Wellman in 1896, the Wellman Co. has long been known for its line of heavy bulk materials handling equipment.

Functions and Education of Welding Engineers

A Conference on "The Functions and Education of Welding Engineers" organized by the British Institute of Welding will be held at Ashorne Hill, England, from September 16 to 18, 1956. Some 22 papers have been promised and will be discussed in four sessions. The first group will deal with the "Functions of the Welding Engineer in

COMING EVENTS

A Calendar of Welding Activity

AWS National Meetings

1956 Spring Meeting:
May 7–11, Statler Hotel, Buffalo, N. Y.

Fourth Annual Welding Show
May 9–11, Memorial Auditorium, Buffalo, N. Y.

1956 Fall Meeting:
Oct. 8–12, Cleveland Hotel, Cleveland, Ohio.

NWSA Zone Meetings:

Sept. 20–21, Hotel Statler, New York City

Sept. 24–25, Hotel LaSalle, Chicago, Illinois

National Metals Exposition:

Oct. 8–12, Thirty-eighth National Metal Exposition and Congress, Cleveland Public Auditorium, Cleveland, Ohio

AN EXAMPLE

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Low Temperature

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AT WORK!

SIMPLE WELD GIVES GIANT CASTING NEW LEASE ON LIFE

This giant iron casting is the 2900 pound transmission case of a Caterpillar D-8 Tractor. When a serious crack developed, it was sent to an independent welding shop—The Superweld Company of Brooklyn, New York—for repair.

Because of its tremendous size and thickness, it was important that the repair be handled properly. Conventional welding materials would require a great deal of preheating which often causes warping, stress and embrittlement of the base metals. To avoid this "Low Temp"® EutecRod® 18FC was chosen.

The repair was made in the following manner: The case was thoroughly prepared by veeing out the cracks for the full thickness of the metal. It was pre-heated *slightly* and filled with Flux Coated EutecRod 18FC. The completed joint required little machining and provided the strength and durability to put the casting into rugged operation again.

Mr. V. F. Reina, General Manager of Superweld, in describing this job, had this to say: "The use of EutecRod 18FC cut down the pre-heating which is ordinarily necessary for brazing so large a casting. In addition, it gave us the excellent tensile strength and tinning action we required."

These comments, from an independent job welding shop, are typical. Tough, even "impossible" repairs have been successfully completed with Eutectic "Low Temperature Welding Alloys"®, because each one has been designed to do a specific job. Weldors have discovered that the warping, stress and embrittlement of base metals associated with conventional welding materials, is minimized or completely eliminated with Eutectic "Low Temperature Welding Alloys" and the exclusive "Low Heat Input" metal joining process. They find that "Low Temp" EutecRods and "Low Amp" EutecTrodes speed welding, save time and money.

Today, with over 160 different, job-engineered "Low Temperature Welding Alloys" to choose from, your Eutectic District Engineer or Representative is ready to show you, right in your own shop, how to cut your production, maintenance, and salvage costs. Why not call him today for your Free demonstration.

More money-saving facts are yours in Eutectic's interesting new Weldor Magazine. Write today for your free copy.

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Industry," the second with "The Present Place of Welding in Advanced Technical Education in this Country," and the third with "The Practice of Other Countries," including the United States, France and Germany. In the last session a number of suggestions for the improvement of the facilities for the education of welding engineers will be described and discussed.

It is expected that the Conference will attract, besides welding engineers, those concerned with technical management in the engineering industry, and teachers of engineering subjects from the universities and technical colleges.

Complete details are available through Secretary G. Parsloe, The Institute of Welding, 2 Buckingham Palace Gardens, Buckingham Palace Rd., London S. W. 1.

Resistance Welding Business Hits New Peak

The February Statistical Report of the Resistance Welder Manufacturers Association, compiled a few weeks ago, again reflects a new record in Association history for new business received in one month.

For February, $6,217,000 in new orders were obtained by Members, and this eclipses the record, posted only in January 1956, by 12%.

Comparing new business for the first two months of this year with the comparable period of 1955, there is a gain of 154%. Shipments for the same two months show an increase of 13% over January and February of last year.

Members of the Association also report an all time record backlog of orders on hand at the end of February of approximately $18,800,000.

Union Carbide Forms Development Company

Union Carbide Development Co. has been formed as a new Division of Union Carbide and Carbon Corp., it was announced by Morse G. Dial, Union Carbide's president. Long-term corporate planning and evaluation of new business opportunities will be important objectives of the new Company.

Operating Divisions of the Corporation will continue, as in the past, to carry on their own research and development activities in Union Carbide's seven major fields of activity: alloys and metals; chemicals; electrodes, carbons, and batteries; industrial gases and carbide; nuclear energy; plastics; and silicones.

Birny Mason, Jr., secretary of Union Carbide, has been appointed president of the new Company, R. E. Cornwell, E. J. Fox, and J. J. Murphy have been named vice-presidents. All of the new officers have been associated with the Corporation for many years.

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Do you know the advantages you gain through AWS Membership? Why not investigate?
Write AMERICAN WELDING SOCIETY, 33 West 39th Street, New York 18, N. Y.

G. E. Appoints Welding Distributor

McJunkin Corp., with headquarters in Charleston, W. Va., has been appointed a General Electric Co., welding distributor. With additional branch offices at Louisville, Ky., and Columbus and Marietta, Ohio, the new distributor will serve all portions of West Virginia, and adjacent areas of Kentucky and Ohio. The corporation will handle the complete line of General Electric welding equipment.

Wall Colmonoy Appoints Representative

Appointment of Krist Leovich, Jr., as sales engineer for the company's west coast sales office has been announced by the Wall Colmonoy Corp. of Detroit Mich.

In his new position as Colmonoy representative, Mr. Leovich will be responsible for application engineering, development and service assistance to users of hard-facing products in California. West coast offices are located at 1565 Bluff Rd., Montebello, Calif.

Two New Directors Appointed by Eutectic

Rene D. Wasserman, president, Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing, N. Y., announced the appointment of two new members of the Board of Directors at the conclusion of a meeting held to inaugurate the firm's latest expansion program.

Joseph Hambuechen, a distinguished financier and for many years an official of the First Boston Corp., will advise the Corporation on domestic and overseas expansion operations. He is a director of a number of leading industrial concerns.

Noel B. McLean, president, Edo Corp.,

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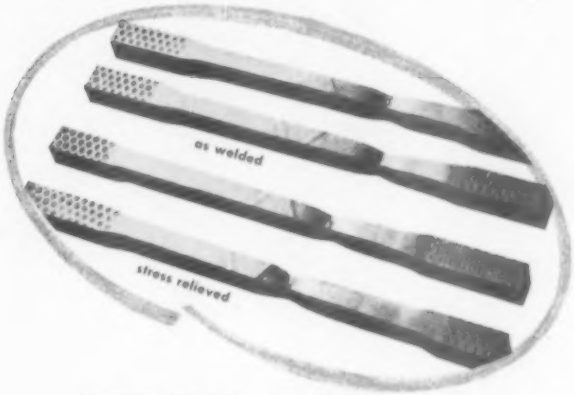
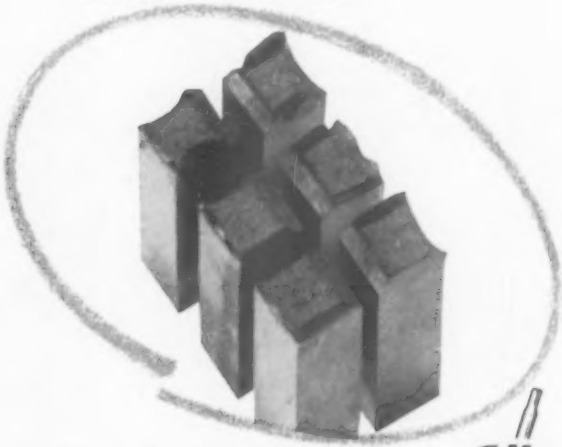


Transverse tensile test bars welded with Atom • Arc "T" electrodes. Notice that all breaks occurred in the base metal.



Notice the ductile fracture in these all weld metal Charpy V notch impact bars broken at —65° F.

Here's the answer to dependable, economical high strength welds on Carilloy "T1" Steel

100% Joint Efficiency

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Ductility and impact values are excellent at low temperatures. Charpy V notch impact values of 29 ft. pounds at —65° F. "as welded", 23 ft. pounds at —65° F. "stress relieved". All breaks under impact show excellent ductility.

Plus

Atom • Arc "T" offers these outstanding plus values for which every Atom • Arc electrode is widely known . . .

X-Ray quality crack-free welds
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Faster deposition rates
Low spatter loss—quick, easy clean-up
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will broaden Eutectic's service to industry by contributing from his extensive experience solving problems related to production welding and brazing. Mr. McLean was formerly connected with Bendix.

Modern Engineering Appoints Phelps

At a recent executive meeting, the Modern Engineering Co., St. Louis, Mo., named Frank N. Phelps, Jr., advertising manager of its Oxy-Acetylene Welding & Cutting Apparatus Divisions.

Mr. Phelps has been active in industrial advertising and marketing since 1927. He will prepare advertising and related material for the firm's distributors and their customers in all fields, domestic and foreign.

Course on Welded Structures Given at Miami University

A three-day Short Course on Design of Welded Rigid Frames was given March 26th, 27th and 28th at the University of Miami, Evening Division, by Martin P. Korn, [illegible], consulting engineer. Admission was limited to professional engineers and architects.

A large span rigid frame designed and built by Mr. Korn was analyzed and followed through from its preliminary design to the shop fabrication and erection.

Mr. C. L. Kreidler, chief structural engineer, Lehigh Structural Steel Co. was invited by Mr. Korn as a special guest lecturer. He gave a most interesting illustrated talk on "Welding the Largest Structures" and his special visit for this occasion gave welding a big boost. Dr. M. I. Mantell of the Civil Engineering Department presented several simple problems showing the savings by plastic design over conventional design. His lecture followed a brief exposition by Mr. Korn on "Philosophy of Plastic Design" which revealed that method as a natural for determining the strength of rigid frames and welding as a natural for savings through plastic design.

Cooperating agencies were the American Institute of Architects, American Institute of Steel Construction, American Society of Civil Engineers, American Welding Society, Florida Engineering Society and the Structural Engineers Council.

Plan to Attend AWS
National Fall Meeting
Cleveland, Oct. 8–12, 1956

NWSA Convention Attended by 759 Delegates

The Twelfth Annual Convention of the National Welding Supply Association broke all attendance records with 759 delegates registering for the sessions at the Hotel Roosevelt, New Orleans, on March 19th, 20th, 21st and 22nd. It was acclaimed to be excellent by the members in attendance. The business programs proved unusually interesting, and featured enlightening, effective addresses. The Ladies' Program and general social functions were well arranged and highly enjoyable; 258 ladies registered at the Convention.

The high point of the Convention was the Annual Banquet on Wednesday evening in the beautiful International Room of the Hotel Roosevelt. James N. Alcock served as toastmaster. Following dinner, C. O. Stilwell of Gulf Welding Equipment Co. was installed as the new NWSA president.

Other officers elected were six vice-presidents and four directors. The six vice-presidents are: Al Earlbeck, R. S. Mars, Jr., H. G. Weiler, J. R. Stewart, L. P. Beaver, Jr., and W. H. Stanfill. The four members elected to the Board of Directors for terms expiring in 1959 are: R. D. Layman, Bob Toll, V. B. Anderson and C. A. Dinsmore.

C. O. Stilwell

Also at the Annual Banquet, Mr. Stilwell announced that the 13th Annual Convention will be held at the Hotel Mayflower in Washington, D. C., on Monday, Tuesday, Wednesday and Thursday, May 13 through 16, 1957.

WELDED STEEL STRUCTURE

Under the spreading arms of a new welded, rigid frame structure, 200 x 400 ft, the Ohio State Buckeyes are going to be able to practice football without regard for rain, sleet or snow—just like sunny California. The photograph shows early stages of the welded steel framework of an indoor practice arena for Ohio State University, now nearing completion on the campus in Columbus, Ohio. The building is a steel structure with a clear span of 200 ft, consisting of 18 all-welded rigid frames. Its huge, almost two-acre, dirt floor will be used for indoor practice of football, baseball and track. (Courtesy of the Lincoln Electric Co., Cleveland, Ohio)

Eutectic Names New Production Manager

Rene D. Wasserman, president, Eutectic Welding Alloys Corp., Flushing, N. Y., has announced the appointment of Harley Erickson as production manager.

Mr. Erickson was formerly general foreman of Production for the Lincoln Electric Co. and Westinghouse Electric Corp. He brings more than 23 years experience in every phase of welding alloy manufacture to Eutectic.

"Welderama" Draws 1000 Guests in Cedar Rapids

Sponsored by the Kacena Co. of Cedar Rapids, Iowa, the "Welderama" industrial exhibit was visited by almost 1000 guests during the two days on which it ran. There were 403 registered guests on March 7th and an attendance of 559 on March 8th. Some came from as far as 170 miles away.

Some 26 participating companies exhibited their products, and about three-fourths of these had live exhibits. Also, continuous motion pictures were shown in a projection room.

In view of its outstanding success, plans are now being made to repeat the "Welderama" in the not too distant future, with greater number of exhibitors and a greater number of live exhibits.

Wolfenden Welding Wins Award

Wolfenden Welding Supplies, Inc., 3500 Prospect Ave., Cleveland, Ohio, has achieved the distinction of finishing in first place among Hobart Bros.' distributors competing in the Volume Sweepstakes for 1955. In a recent presentation, the company was cited for its outstanding work in building sales for welding equipment, electrodes and accessories, giving them the largest volume of business of any Hobart distributor. Second place went to Hobart Welding Accessories, Inc., Long Island City, N. Y., and third place to H. K. Miller, Inc., Chicago, Ill.

Volume Sweepstakes award of the year is presented to Wolfenden Welding Supplies, Inc. by Bill Howell, manager of distributor sales for Hobart Bros. Co. *(Left to right)* Bill Howell, John T. Wolfenden, Jr., Mrs. J. T. Wolfenden, Sr., Bill Wolfenden and Dick Sherwood, territorial manager for Hobart Bros.

WELDING EXHIBIT HELD IN CEDAR RAPIDS

Shown above are four typical scenes taken at the "Welderama" held in Cedar Rapids, Iowa, on March 7 and 8, 1956

"I recommend the Airco 387 Electrode for welding mild steel"

It's the most versatile of all 6012 electrodes. Good wetting action of the Airco 387 electrode permits the use of high current and travel speed on both thick and thin sections. The fluxing action of the slag results in smooth, uniform deposits of superior appearance with minimum spatter. Especially recommended for single pass horizontal fillet welds because of ease of handling, good weld profile and ability to withstand high welding current.

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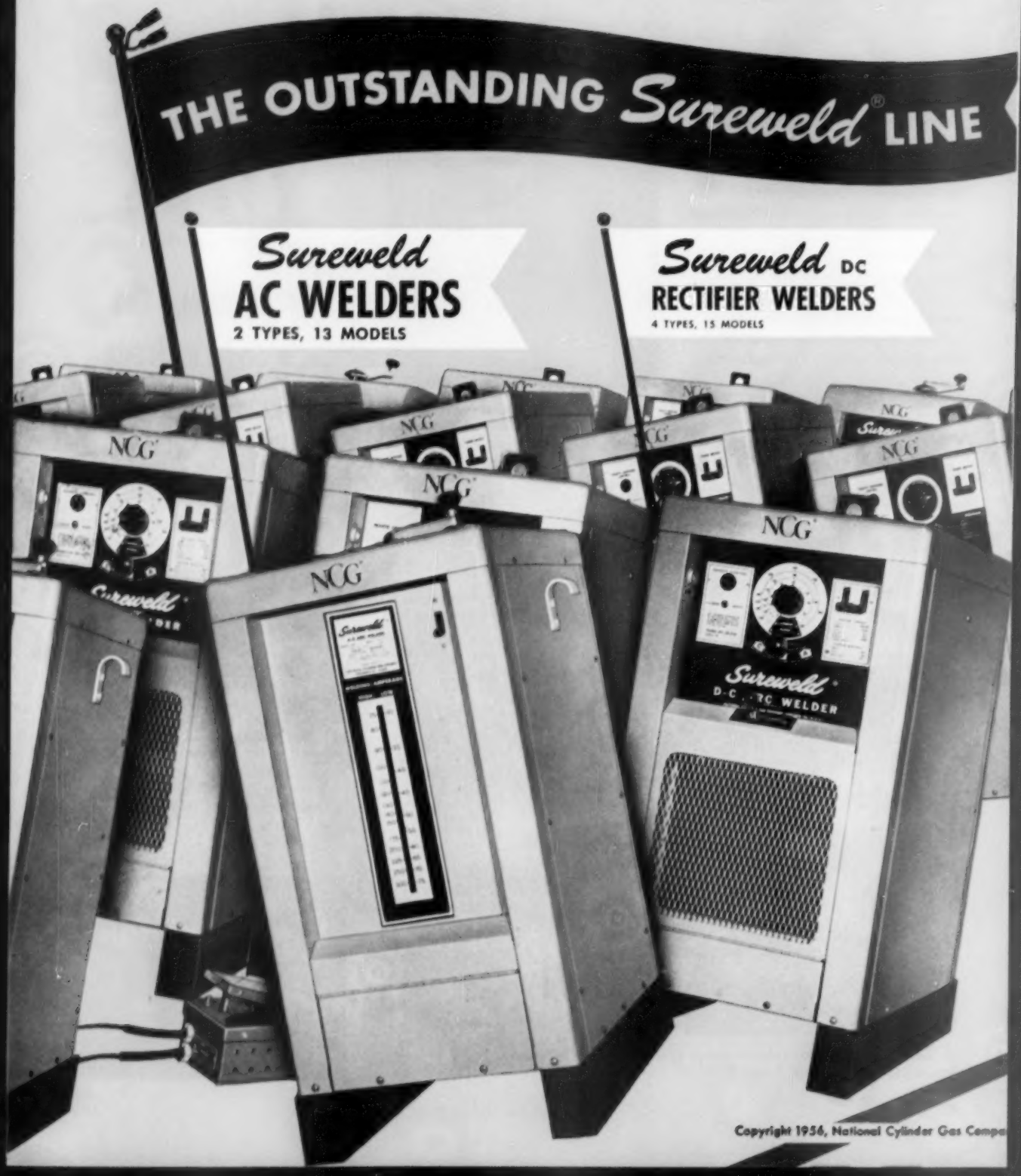

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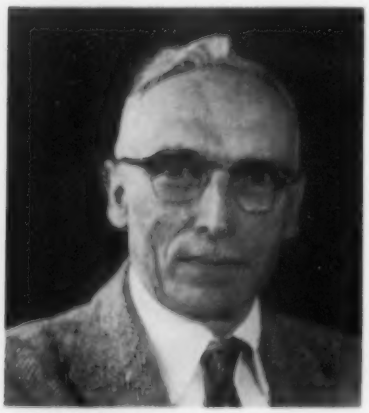
PERSONNEL

D. L. Mathias Retires

D. L. Mathias retired as research engineer from Arcrods Corp., Sparrows Point, Md., effective April 16th. Upon graduation from Carnegie Institute of Technology in 1914, he engaged in metallurgical and related activities until the end of 1928. At that time, Mr. Mathias entered the field of welding with Westinghouse Electric & Manufacturing Co. at East Pittsburgh, Pa., where he initiated their research and development work on bare and coated electrodes.



D. L. Mathias

In 1936, he took up employment with Metal & Thermit Corp., at Jersey City, N. J., and later at Rahway, N. J., where he was in charge of research and development on electrodes and welding applications. He transferred to Arcrods Corp. in 1950 in the capacity of research engineer and was employed there until retirement.

Mr. Mathias has authored numerous papers and took out many patents pertaining to welding. After retirement, he will continue to engage actively as a consultant on welding research and development problems. His headquarters will be located at 98 Elliott Place, East Orange, N. J.

Rupp Wins Salesman's Award

Aaron Rupp, Eutectic district engineer for Michigan area, has been named by the National Sales Executives Club as the first representative of a welding manufacturer to be honored with its Distinguished Salesman's Award.

Presentation of the Victor Trophy was made to Mr. Rupp by the Hon. James A. Farley, chairman of the Board, Coca-Cola Export Corp., during the Sales Executives Club's annual DSA presentation ceremonies. The award was made in New York on Friday, March 2nd, before more than a thousand sales executives and officials of American industry.

The Distinguished Salesman's Award is given as public recognition of outstanding service to industry in a sales capacity. Only one man from a participating company can receive the DSA Victor Trophy annually. The DSA program is sponsored jointly by the Sales Executives Club and leading manufacturers to call attention to salesmanship as the "spark plug of the economy."

Mr. Rupp has served industry in the Midwest automobile manufacturing centers since 1944 when he joined Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N. Y., as a district engineer. He is a member of the AMERICAN WELDING SOCIETY.

Conner Appointed by Standard Steel

The Standard Steel Corp., Los Angeles, has announced the appointment of G. A. Conner as chief inspector and welding engineer.

Mr. Conner, will be responsible for quality control, preparation and development of welding procedures and testing. His 20 years experience covers problems related to the fabrication of diesel locomotives, pressure vessels, nuclear energy work and diversified job-shop.

Mr. Conner holds memberships in the AMERICAN WELDING SOCIETY and the American Society for Metals.

G. A. Conner

Forman Made Vice-President

Milton Forman has been appointed vice-president of Alpha Tank Co., Inc. of Long Island City, N. Y. He will be responsible for production, research and development.

Mr. Forman is a registered professional engineer in the states of New York and Ohio. He is a member of the American Society for Metals and AMERICAN WELDING SOCIETY.

He is active on a number of committees including, the Structural Steel Committee of the Welding Research Council, the Special Sub-Group on Design and Workmanship of the Conference Committee on Welded Bridges of the AWS.

Formerly, Mr. Forman was employed as welding and metallurgical engineer of Todd Shipyard, National Supply Co., and Ingalls Shipbuilding Corp.

Meredith Honored by Los Angeles Section

As reported briefly in the April issue of THE WELDING JOURNAL, a bronze plaque was recently awarded by the AMERICAN WELDING SOCIETY Los Angeles Section to Russell Meredith,

Russell Meredith

supervisor in the Materials Research and Process Development Group of North American Aviation's Missile Development Division in Downey "for outstanding contributions to advancing the art and science of welding."

This major award of the local AWS Section for 1956 was made on the basis of Mr. Meredith's numerous achievements in his field. He holds basic pat-

ents on the inert-gas tungsten-arc welding process, important to the aircraft, missile, and rocket engine industry. His method for automatic, continuous inert-gas tungsten-arc welding of long structural members for airframes is a significant contribution to operations at the Downey plant.

Heiden and Loup Promoted by Progressive Welder

Progressive Welder Sales Co., 3070 East Outer Dr., Detroit, Mich., announces the appointment of Ray W. Heiden as director of Manufacturing in charge of the company's entire manufacturing operations. He has long been active in manufacturing management at Progressive.

Ray W. Heiden

Ronald L. Loup

At the same time, it announces the appointment of Ronald L. Loup as director of Engineering for all the company's divisions. His promotion immediately follows his recent elevation to chief engineer of the welding machine division. Mr. Loup is a member of the AMERICAN WELDING SOCIETY.

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ABSTRACTS OF CURRENT PATENTS

prepared by Vern L. Oldham

Printed copies of patents may be obtained for 25¢ from the Commissioner of Patents, Washington 25, D. C.

2,735,920—Welding Current Contact Tube—Leopold Valliere, Montreal, Quebec, Canada, assignor to Air Reduction Co., Inc., New York, N. Y., a corporation of New York.

In the patented welding apparatus, a tubular welding current contact member of electrically conductive material is provided and has a smooth bore through which the electrode is passed in contact therewith for presentation to the welding arc. A ring of refractory material is provided on the end of this electrically conductive member immediately adjacent to the arc and has an inner diameter substantially equal to the diameter of the bore in the contact member.

2,736,027—Pivot Mounting for Welder's Face Shield—Alfred F. Parmelee, Kansas City, Mo., assignor to Parmelee Plastics Co., Kansas City, Mo., a corporation of Missouri.

Parmelee's patent is on a special positioning means used for pivotally securing a U-shaped face shield member on a headband in a welder's face-shield article.

2,736,090—Cold Pressure Welding—Anthony Bagnold Sowter, Ickenham, and Raymond Kenneth Hilton, West Dulwich, London, England, assignors to The General Electric Co. Ltd., London, England, a British company.

This patent is on a method of producing a cold pressure spot weld between two superposed metallic members of pressure weldable material. The method comprises applying indenting pressure to opposed areas of the members so that the characteristics of the strength of the joint as a function of increasing indention increases at first relatively rapidly to a point of peak strength and decreases gradually with increasing indentation as a result of work hardening. The pressure applied is controlled to effect welding in the gradually decreasing strength portion of the pressure welding indentation to insure welds of consistent maximum strength which are substantially free from the effects of work hardening of the weld metal.

2,736,787—Arc-Welding Apparatus—Alanson U. Welch, Jr., West Townsend, Mass., assignor to General Electric Co., a corporation of New York.

Welch's patent relates to arc-welding apparatus including a metallic guide having an electrode passageway therethrough, and a fiber tip is mounted on the discharge end of the metallic guide and also has an electrode passageway therethrough. This tip has such a length that, when the fusion rate of the electrode is greater than its feeding rate, the tip prevents the passage of the arcing terminal of the electrode through the tip and into engagement with the metallic guide prior to arc extinction due to a lengthening of the arc gap beyond that at which the welding current maximum voltage will maintain an arc.

2,737,140—Welding Frame—Luther D. Totten, Los Angeles, Calif.

Totten's patent is on a special frame for axially aligning and force-rounding the adjacent ends of two end-abutted pipe sections prior to effecting a welding action thereon.

2,737,150—Welding Electrode and Method—Charles T. Gayley, Lansdowne, Pa.

An arc-welding electrode of the low-hydrogen type is covered in this patent. The electrode includes a metallic rod having a coating including specified percentages of marble flour, fluorspar, potassium silicate and other specific ingredients.

2,737,563—Methods of and Apparatus for Making Tubes—Paul J. Abel, Cleveland, Ohio, assignor to The Yoder Co., Cleveland, Ohio, a corporation of Ohio.

Abel's patent is on an apparatus for continuous manufacture of welded tubing and includes forming means for shaping a continuous metal strip to generally tubular form with the edges of the strip closely opposed to present a continuous longitudinal seam. Other means advance this tube which is heated to raise the seam edges to welding temperature. Other means force the edges together in welding engagement and guide means properly position the seam relative to the heating means. Such guide means include special rollers, one of which has a tapered peripheral flange for entering the seam provided on the shaped tubing blank.

2,737,564—Compound Tip Welder Tool—William A. Barnes, Utica, N. Y., assignor to Utica Drop Forge & Tool Corp., a corporation of New York.

A portable tip-welding tool is covered in this patent. The tool includes first and second handle members closable together through a first closing range and a second closing range. Special linkage means between the handles and electrode means provided function to drive the electrode means toward the jaws upon closing movement of the handles through the second closing range. Another member limits the movement of the electrode means toward the jaws to a predetermined maximum approach.

2,737,565—Welding Tool Manipulator—Amel R. Meyer, Griffith, Ind., assignor to Graver Tank & Mfg. Co., Inc., East Chicago, Ind., a corporation of Delaware.

Meyer's patent is on a tool manipulator for submerged arc welding of an upright seam between stationary shell plates. The apparatus includes movable frame means for supporting welding shoe means for the welding action, and path defining means are operatively connected to the frame means for guiding it during its movement in relation to the seam. Other means are provided to establish pressure between the shoe means and the seam and another element keeps the pressure substantially uniform regardless of movement of the frame means.

2,737,566—Method of Butt-Welding Preheated Metallic Workpieces—August Theodor Wuppermann, Leverkusen-Schlebusch, Germany, assignor to Theodor Wuppermann G. m. b. H Leverkusen-Schlebusch, Germany, a firm.

Relatively massive workpieces of substantially full cross section at the faces to be welded together are referred to in this patent. The faces are aligned at a predetermined distance apart and then are preheated by high-frequency induction until substantially uniformly heated across each entire face. The gap between the faces is quickly reduced and immediately a low-tension arc is initiated between the faces at the closer distance to clean such surfaces and to attain uniform welding heat while maintaining a non-oxidizing atmosphere between the faces. The faces are caused to approach each other while simultaneously maintaining the relatively low-tension arc until contact is attained. Lastly the workpieces are forced together to facilitate fusion of the contacting faces.

2,737,567—Method of Making a Jointing Piece—Endre Bohner and Jozsef Lukacs, Budapest, Hungary, assignors to "Licencia" Talalmanyokat Ertekesito Vallalat, Budapest, Hungary, a firm.

This patent relates to a method of making a jointing piece for connecting light metal cables to copper cables. The method comprises making two bodies of

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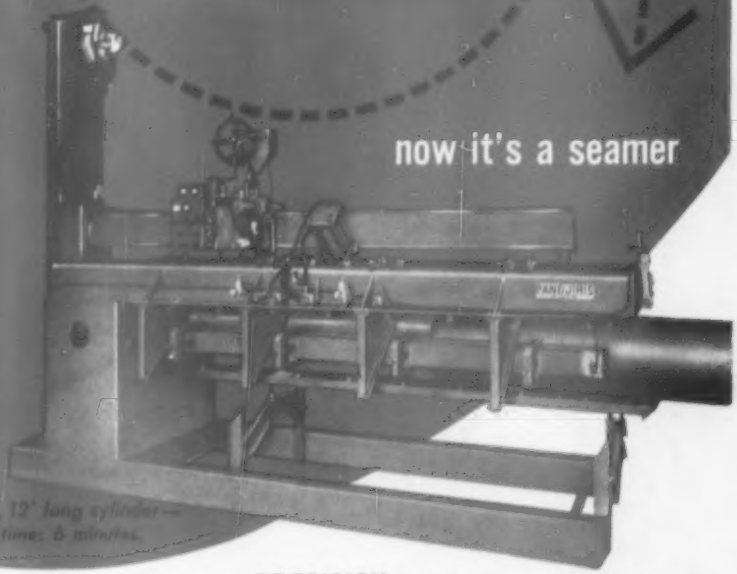

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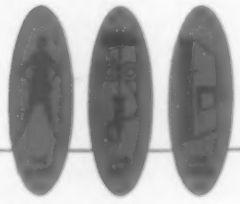

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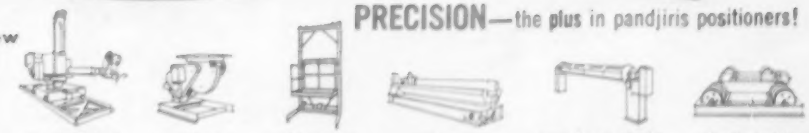

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the same cross section and with one of the bodies being of copper and the other being of the light metal to be joined to the copper. A silver wafer is hard soldered to the copper body, and a series arrangement or assembly is built up from the copper body, the silver wafer soldered to the copper body, a silver powder layer and the light metal body. Then pressure is applied to the assembly while passing a shock-like surge of electricity through the series assembly until bonding of the silver powder layer with the adjacent metal parts is completed.

2,737,568—Process for Welding Thin Sections of Spring Steel—Calvin B. Rountree, Tappan, N. Y., assignor to The Western Union Telegraph Co., New York, N. Y., a corporation of New York.

A method of securing together a plurality of ferrous members including a spring steel strip is covered in the patent. The method includes the steps of stacking the members in a desired relation, providing nickel in superposed layer form external to the spot to be joined, and applying resistance welding means to the stack. These welding means are energized by capacitive discharge for interfusion of the stack members and nickel.

2,737,710—Method of Making Welded Joints—Wiley B. Noble, Ford T. Evans and Charles C. Goolsbee, Houston, Tex., assignors to Reed Roller Bit Co., Houston, Tex., a corporation of Texas.

This patent relates to a method of connecting a tubular member to a second member wherein such second member has an annular projection of substantially the same cross-sectional thickness as the tubular member and wherein the adjacent ends of the tubular member and the projection are to be welded to each other. A cylindrical extension is provided on the second member and extends beyond the annular projection which encircles and is concentrically disposed with relation to said cylindrical extension. The method includes the steps of forming the bore of the tubular member to substantially the same diameter as the external surface of the extension, and shrink fitting the extension into the bore of the tubular member to connect the members with the end of the tubular member in spaced relationship to the annular projection. Then adjacent ends of the tubular member and projection are welded to each other.

2,738,643—Method of Making Non-Kinking Chain Links with a Single Weld—Fred B. Money, Thorofare, N. J., and Charles D. Linnenbank, Chester, Delaware County, Pa., assignors to Baldt Anchor, Chain & Forge Division of the Boston Metals Co., Chester Pa., a corporation of Maryland.

A method of forming a chain link from a continuous length of metal bar by one weld is disclosed in the patent. The method comprises bending the bar near its end in a small radius curve to provide an integral stud, and the remainder of the bar is bent to link-form about the stud and the link end is positioned adjacent to the stud end where it connects to the remainder of the link. Then the link end is welded to the outside surface of the stud bend to complete the link.

2,739,215—Weld Current Meter and Monitor—Hubert W. Van Ness, Buffalo, N. Y., assignor to Westinghouse Electric Corp., East Pittsburgh, Pa., a corporation of Pennsylvania.

Van Ness' patent is adapted to monitor the operation of a welding system and includes the combination of means adapted to be connected to the welding system for preventing the system from performing a welding operation unless such means is actuated and to condition the system to perform a welding operation when actuated. Another member is provided responsive to the magnitude of the welding current during the welding operation for actuating the said means if the magnitude of the welding current lies within the predetermined range and to prevent the said means from being connected for conditioning the system to perform a succeeding welding operation if the magnitude is outside of the predetermined range. Yet other means are provided responsive to the system after it has been conditioned prior to each welding cycle and while the welding cycle is in progress but before welding current flows for setting the magnitude responsive member to respond as stated during the welding cycle.

2,739,216—Coolant Flow Control for Electric Resistance Welders and the Like—Joseph J. Riley, Warren, Ohio, assignor to the Taylor-Winfield Corp., Warren, Ohio, a corporation of Ohio.

The present patent relates to welding apparatus having a primary energy circuit and means for supplying coolant to critical parts of the apparatus. Particularly, the patent relates to an improved circuit for controlling the flow of coolant which circuit includes an electronic valve having an anode, cathode and control electrode, while means responsive to the condition of the valve are present for controlling the flow of coolant fluid during periods of non-conductivity of the valve and to prevent the flow of coolant fluid during periods of conductivity of the valve. Means are provided for rendering the electronic valve non-conductive for timed periods and including a control electrode and a capacitor-potentiometer network. The primary energy circuit is adapted to charge the capacitor for rendering the electronic valve non-conducting and the arrangement is such that upon energization of the primary energy circuit, the capacitor is charged, and upon deenergization of the primary energy circuit, the capacitor discharges at a timed rate to render the electronic valve conductive for a predetermined time following deenergization of the primary energy circuit.

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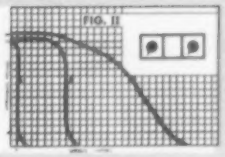
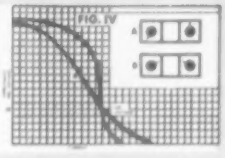


Maintains good arc stability through the complete current range from extremely low to extremely high without range switches.



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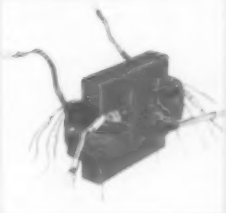
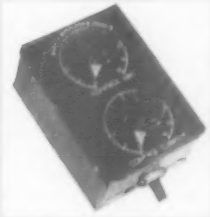


Exclusive, patented Magnetic Amplifier combines fine control with ruggedness and durability.



Exclusive dual remote control equipment available provides close control of complete current and voltage range.

WRITE TODAY for complete information and literature on these and other items of versatility such as low spatter performance on special electrodes, etc.

Some territories open for qualified dealers. Write for details.

VICKERS ELECTRIC DIVISION

VICKERS INCORPORATED a unit of Sperry Rand Corporation

1853 LOCUST STREET • SAINT LOUIS 3, MISSOURI

NEW PRODUCTS

800-Amp Rectifier Welder

A new 800-amp rectifier welder for gas-shielded, consumable electrode welding has been announced by the General Electric Co.'s Welding Department.

Available in three models to meet varying application requirements, the new welder features quiet operation, a combination cleaning-cooling fan, easily removable side covers, and Class H silicone insulation. An infinite number of welding voltages within the unit's rating will suit any condition of gas, and size

and speed of wire, according to company engineers.

All three models are rated at 800-amp output, 15 to 40 v continuous; 95% power factor; 78% efficiency; and 41-kw input. They weigh approximately 620 lb and are 44 in. high, 31 in. wide, and 26 in. deep.

For complete details, write directly to General Electric Co., Welding Department, York, Pa.

Heat Program Control

A new heat program control timer for use in resistance welding is announced by the Raytheon Manufacturing Co., Waltham, Mass. According to the manufacturer, this new unit makes it possible to weld metals that are oxidized, or those not readily cleaned. The control supplies welding current in three successive periods. The first period "conditions" the metal surfaces by burning through the coating with increasing current. Second, constant current welds the metals. Third, decreasing current anneals the weld. The duration of each period may be varied through a heat range of 20–100%. The only bench-mounted unit of its kind, it is used with a Raytheon thyratron contractor. It is especially designed for ease of operation

and may be used with a variety of welding heads.

For complete details write to section WJ, Equipment Marketing Dept., Raytheon Manufacturing Co., Waltham, Mass.

Magnetic Plate Clamp

The availability of an electromagnetic plate clamp, designed to aid in industrial welding jobs, is announced by Portomag, Inc. Equipped with a ratchet lever jack, and a heavy duty (3000 lb) magnetic pull, this new welding unit can be used for many welding situations, according to the manufacturer. One of its most important applications is its use in plate alignment work for butt-welding operations. Its heavy duty power is sufficient to straighten out warped sheet steel and its ratchet operated jack can be used for plate alignment work. This heavy

duty electromagnetic unit can also be used as a lift in many production situations.

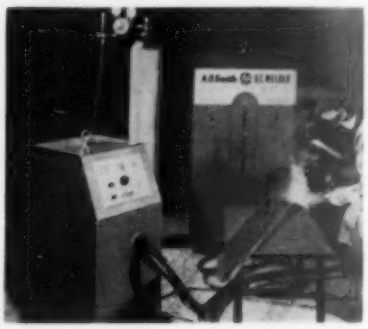
For complete details, write to Portomag, Inc., 1511 E. Nine Mile Rd., Ferndale 20, Mich.

Semi-Automatic Welding Process

A complete semiautomatic hand-gun welding process designed specifically for use with carbon dioxide is announced by the Welding Products Division of the A. O. Smith Corp., Milwaukee 1, Wis. Known as C-OMANUAL, it uses CO_2 gas to shield the arc.

This compact, portable process contains a hand gun, control unit and a special A. O. Smith 600-amp d-c power source.

According to the manufacturer, the C-OMANUAL process was designed to fill the need for a welder that offers the welding speed advantages of fully auto-



matic operation without the related high-jig fixture tooling costs. It is reported to feature the following characteristics:

(1) Automatic control of current compensates for all operators' variations of arc length. This eliminates back burning and stubbing.

(2) Process affords deep penetration and high-metal deposits with sound quality and high-strength and ductility characteristics.

(3) Visible arc speeds the spotting of the nozzle, for faster, easier welding. No flux is needed, and subsequent slag removal problems are elimi-

nated, giving clean, non-porous welds.

(4) Wire speeds up to 600 ipm make the C-OMANUAL process as fast or faster than any semiautomatic process in existence, the Welding Process Division asserts.

Consumable Inserts

Inert-gas tungsten-arc welding of piping without backing rings, smoother root pass welds with elimination of root pass cracking and improved weld contours in thin wall piping with one or two less passes, are some of the benefits claimed by a line of new consumable solid insert rings available from the Industrial Piping Division of Grinnell Co., Inc., Providence, R. I.

Insert ring materials commonly available are: mild steel; alloy steels $1\frac{1}{4}$ Cr – $\frac{1}{2}$ Mo, $2\frac{1}{4}$ Cr – 1 Mo, 5 Cr – $\frac{1}{2}$ Mo; stainless steel Types 304, 304 ELC, 310, 316, 316 ELC, 347 (A) (fully austenitic) and 347 (F) (4-6% ferrite).

Technical information describing welding procedures is available upon request by writing to Grinnell Co., Inc., Industrial Piping Division, Providence 1, R. I.

Hard-facing Powders

Nickel base alloy powders for hard facing that can be sprayed from various types of guns and applied to practically all metals with melting points above 1850° F have been developed by Western Carbide Corp., subsidiary of Superweld Corp., N. Hollywood Calif. Called Hi-C Spray Powders, the new product is said to provide a homogeneous deposit of high hardness with

New AMPCO-BRāZ #1 —a "3-in-1" Filler Rod

for

- *silver-like, high-strength joints*
- *low-friction overlays with good bearing qualities*
- *corrosion and wear resistance*

Here's a non-fuming, low-melting-point rod that gives you attractive welds with high strength. Ampco-Brāz #1 has a special "controlled" composition that permits both joining and overlay with the oxy-acetylene process.

A wide variety of copper-base, iron- and nickel-base metals and alloys can be joined with this new copper-alloy filler rod. It produces strong, silver-like welds of 85,000 p.s.i. tensile strength with 160,000 p.s.i. shear strength—in bevelled-butt, fillet, and straight-butt joints. There's no warpage or distortion. Ampco-Brāz #1 is excellent for tough overlays, too, because it resists corrosion and wear.

Ampco-Brāz #1 is ideal for all-position welding, and is easy to apply — uses ordinary brazing fluxes and techniques. It goes on rapidly at low cost because a larger flame can be used without "burning" the alloy. A low bonding temperature and low melting point results in smooth, dense, free-flowing deposits.

Order new Ampco-Brāz #1 from your nearby Ampco distributor or write us for more information.

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AMPCO®
The Metal without an Equal

AMPCO METAL, INC.
Dept. WE-3 • Milwaukee 46, Wisconsin
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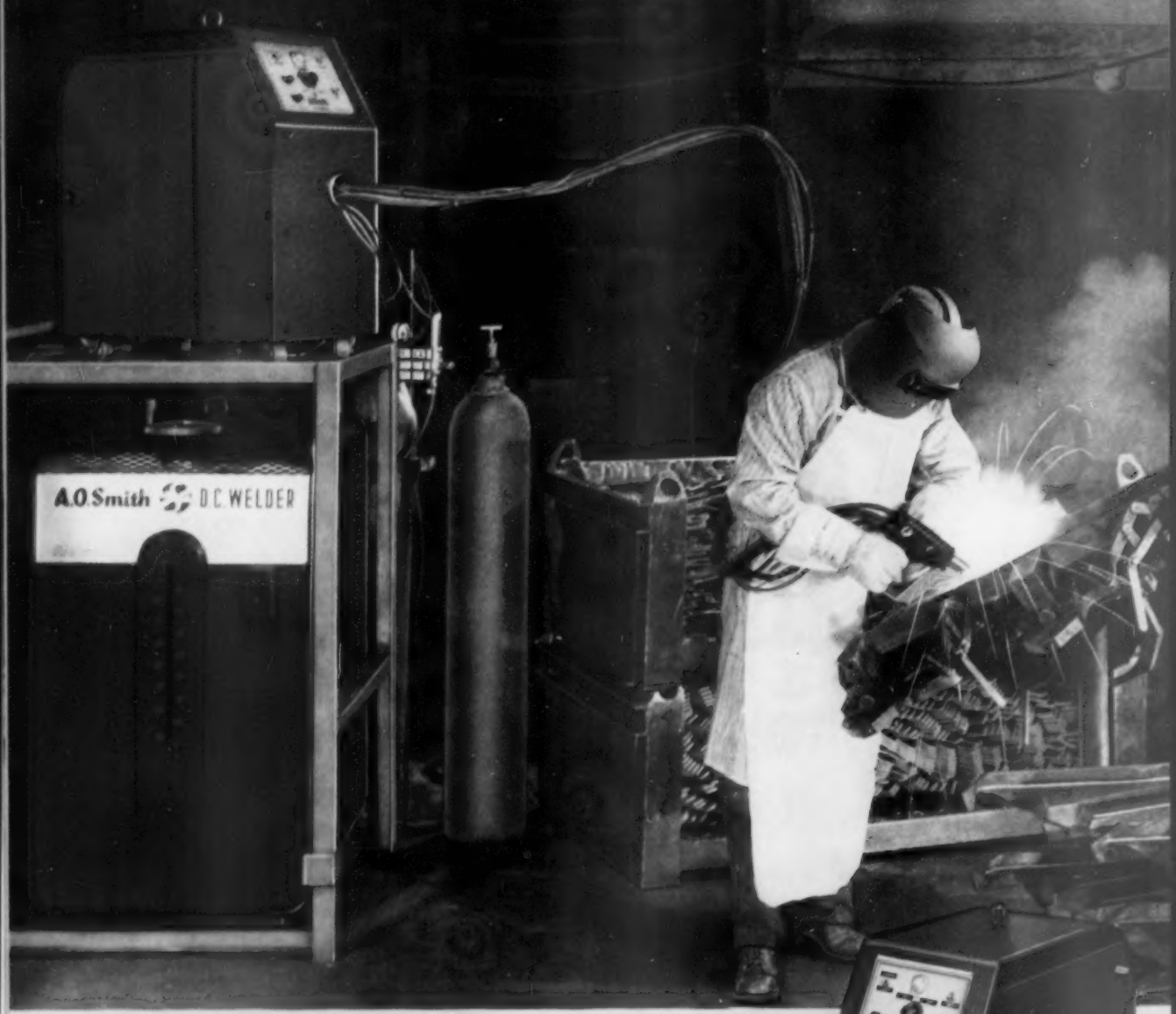
W-530

All New... A.O.Smith



NEW FEATHERWEIGHT HAND GUN

. . . is as easy to use as pointing your finger. Water-cooled, it has no "O" rings . . . eliminates leakage. Ends necessity for complicated switchovers when changing wire sizes. All connections are fully protected Streamline design increases visibility.

C-OMANUAL

Carbon Dioxide Hand Gun Welding

...offers amazing economy and high degree of automation!

★ **Cuts gas cost to practically nothing!**

1¢ per cubic foot for carbon dioxide as compared to almost 7¢ for Helium and 9¢ for Argon . . . and you use much less. Savings in gas alone will more than pay for your C-OMANUAL unit in several months.

★ **Clean slag-free welds!**

No flux to clean, no chipping, no scraping.

★ **Fast, fast, fast!**

Several times faster than the fastest stick electrodes . . . as fast, or faster than any semi-automatic process in existence.

★ **Visible arc**

Keeps you in the groove . . . assures consistent weld quality. Speeds spotting of nozzle.

★ **New simplicity of operation**

There's no constant fiddling with settings. Console automatically controls arc length . . . compensates for operator's arc distance variations.

★ **Deeper penetration**

Assures sound, uniform welds with excellent strength and ductility.

SEEING IS BELIEVING — Try C-OMANUAL yourself at the AWS Show, A. O. Smith Booth No. 90. For complete facts and information on availability, contact your man from A. O. Smith.

COMPACT, EASILY PORTABLE CONTROL CONSOLE

Mounted on free-rolling rubber casters, the control console is easy to move from spot to spot. It contains wire reel, feed and speed controls, easily traced electrical circuits and all gas and water connections — *plus the exclusive two-speed head* which allows operator to get proper feeds for light or heavy wire by mere flick of selector switch. Controls on front panel are conveniently grouped, easy to read.

Through research ... *a better way*

A.O.Smith

CORPORATION

WELDING PRODUCTS DIVISION

Milwaukee 1, Wisconsin

INTERNATIONAL DIVISION: Milwaukee 1, Wis.

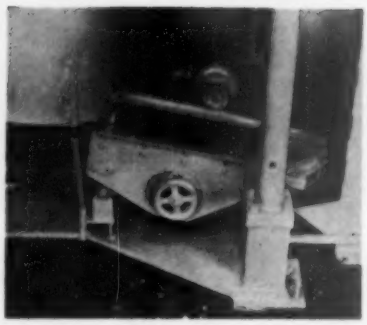
excellent resistance to wear, corrosion and oxidation at high temperatures. Suitable for use in automotive, electrical, farm tool and earth-moving equipment industries, the spray powders permit the selection of any Rockwell C hardness required. The number following the Hi-C designation indicates the Rockwell C scale hardness; a Hi-C 60 spray powder has a minimum Rockwell C scale hardness of 60. Hi-C spray powders are available in hardnesses of 40, 50 and 60.

For additional information, write R. E. Jones, Superweld Corp., 6840 Vineland, N. Hollywood, Calif.

Gyrating Flux Screen

Simplicity Engineering Co. announces the introduction of a gyrating flux screen, designed to screen flux for automatic submerged arc welders. The unit removes scrap and fused flux from the usable flux. Screened flux is discharged into the boot of a bucket elevator and returned to the automatic welding machine.

According to manufacturer, these flux screens have balanced mechanical action which concentrates vibration on the screen deck and transmits little or no vibration to the welding machine.

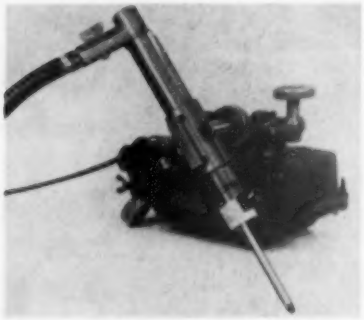


The units are available in sizes 10 x 30 in. and 10 x 50 in., and may be designed to fit various types of automatic welders.

For further information write to Simplicity Engineering Co., Durand, Mich.

Automatic Travel Torch

Arcair now offers a new model L-3 automatic travel torch which, according to manufacturer, makes gouges as smooth as those cut by any machine operation—on all metals! Formerly only manual models of the Arcair torch were available, and this new model is said to offer many advantages over the other model torches on certain operations. It does not replace the hand-held models.



This new model is claimed to be especially valuable on applications requiring long gouges, cuts or bevels, and where there are no intricate configurations or complicated lines of travel. The model L-3 is positively held and moved by a machine on a track. On circumferential seams it is held in a fixture with the work rotated. The speed of travel can be predetermined and set at a constant rate for maximum efficiency which makes possible greater speed and smoothness than by hand.

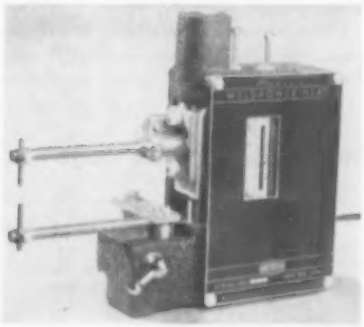
The model L-3 Arcair torch is designed to take electrodes up to $^{3}/_{8}$ in. in diameter, and a larger model L-5, for electrodes up to $^{5}/_{8}$ in., is also available.

For complete details, write to Arcair Co., 419 S. Mt. Pleasant St., Lancaster, Ohio, and Bremerton, Wash.

Safety Plus Super Control!
NEW
Meco
DUBBL STAGE
REGULATOR
• Stainless steel diaphragm on both stages. Won't set... lasts indefinitely. Prevents crimping, distortion.
• Bronze construction—extra safe, longer lasting!
• Pin-point pressure regulation!
• Safe-T-Chek Valve prevents seat damage!
• Designed for quick, on-the-spot repairs! Seats easy to change.
• Versatile! Adaptable for use on oxygen, acetylene, hydrogen, nitrogen, argon and helium.
Distributors! Some territories available. Write!
Meco
3403 PINE BLVD. • ST. LOUIS 3, MO.

Production Welding Head

Designed for use with a-c (to 1.5 kva) or d-c (to 60 watt-seconds) power supplies, the new Model "J" Weldpower® welding head is now available from Raytheon Manufacturing Co., Waltham, Mass. Applications of the unit include welding miniature and subminiature parts such as those used in



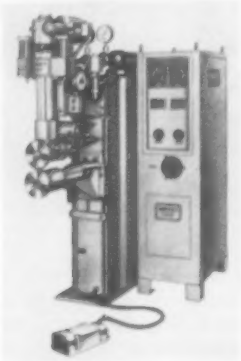
transistors, thermocouples, lamps, electrical instruments, etc. Foot-treadle operated, the "J" head produces clean spot welds at high speeds with minimum of operator fatigue, according to manufacturer. The unit is said to be designed for high visibility of workpieces and good work-handling freedom at the electrodes. Fast electrode follow-up and accurate forging pressure assure uniform production welding.

For complete details, write to Section WJ, Equipment Marketing Dept., Raytheon Manufacturing Co., Waltham, Mass.

Seam Welder

Sciaky Bros., Inc., 4915 W. 67th St., Chicago, Ill., announce the new design of a standard, air-operated, press-type Sciaky MP1 single-phase seam welder.

This welder is one of a series of sizes ranging from 1 through 5. Available in 50 and 75 kva at 50% duty cycle.



Throat depths range through 24, 30, 36, 42, and 48 in. Maximum electrode force of 1000 lb at 80 psi is available.

The MP 1 will readily weld a wide range of mild and stainless steel at efficient production wheel speeds. It is suitable to a wide range of commercial welding applications.

For more complete information about the MP 1, write Public Relations, Dept. M-8 at the Chicago address, requesting Bulletin 316-7. For illustrated stories of seam-welding applications, write for your free copies of "Resistance Welding at Work," Vol. 3, Nos. 6 and 7.

Arc-Welding Machines

Three new arc-welding machines—a d-c rectifier, an a-c d-c rectifier for metallic arc welding and an a-c d-c Heliwelder for inert-gas and metallic arc welding—are now available from Air Reduction.

The Airco single-range d-c Bumblebee rectifier has improved selenium rectifiers designed especially for welding service

to convert alternating current to direct current. It features a single range of current adjustment. New low design permits stacking for parallel operations. It is available in 200-, 300- and 400-amp models.

The Airco a-c d-c Bumblebee rectifier is designed specifically for metallic arc welding and will supply either a-c or d-c current by the flick of a switch. Patented control circuit eliminates need for any mechanical-type control and selenium rectifiers are specifically designed for welding duty. It is available in 200-, 300- and 400-amp models, with or without power factor correction.

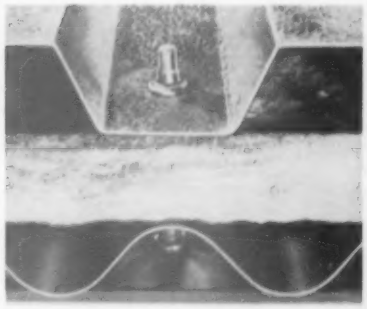
The Airco a-c d-c Heliwelder machine is available in 200- and 300-amp models. They are designed for use with the various inert-gas arc-welding processes in addition to metallic arc welding. These machines consist of a single-phase transformer, selenium rectifier and stabilizing reactor, permitting the operator to select either a-c or d-c welding current.

Additional information about these new arc-welding machines may be obtained by writing Air Reduction Sales Co., a division of Air Reduction Co., Inc., 60 E. 42nd St., New York 17, N. Y.

Stud-Welded Construction Fastener

A new stud-welded construction fastener with an aluminum cap which reportedly permits faster field-assembly and improves the appearance of insulated metal sandwich and other curtain walls, has been developed by the Nelson Stud-Welding Division of Gregory Industries, Inc., Lorain, Ohio.

Identified as the "Setlok" fastener, and already used extensively in attractive, weathertight Fiberglas-insulated metal buildings, the new fastening



system employs a steel-shoulder type stud with serrated tip which is end-welded to structural girts with the Nelson stud-welding gun.

For complete details, write to manufacturer at above address.

Plastic Headgear

The Sellstrom Mfg. Co., 306 Hicks Rd., Palatine, Ill., has announced the production of their new "R" plastic headgear for welding helmets. The company says that it is made from the toughest plastic now known and will stand up under extreme temperature conditions.

A special feature is the new type of sleeve which encloses the gear teeth in the ratchet part of the assembly. It is made up of a closed plastic sleeve so the gear teeth will no longer be exposed, and prevents grease or dirt from getting into the operating mechanism.

Another feature is the new plastic band which can be bent, creased or flexed without breaking.

Further information about this new plastic headgear can be obtained by writing direct to the manufacturers.

Safety Cap and Goggle

"Supergard" safety cap and cover glass welding or chipping goggles in balanced combination, is announced by the Safety Division of the Boyer-Campbell Co., 6540 St. Antoine, Detroit 2, Mich., for those requiring both eye and head protection. Goggles, cover glass style, can also be comfortably worn over personal glasses, according to the manufacturer. These goggles, adjustable for pupilary distance have individual cup action for good fit.

The "Supergard" cap has a full floating, plastic, completely sanitary headgear—with headsizes adjustable from $6^1/_2$ to 8. When reissued, the only thing that need be changed is the sweatband.

For complete information, write directly to manufacturer at above address.

WATCH WESTINGHOUSE

A great new line of welding machines is now rolling off the production lines . . . for you.

See our complete new line of welders that means *another* step ahead in Westinghouse welding leadership. Machines like the new industrial a-c and d-c welders. New utility machines. Completely automatic welders using inert gas, CO_2 and submerged arc.

New features like exclusive "wide-amp control"; 100% duty-cycle arc drive; new superior core and coil construction—double-dipped and baked in silicon-fortified Bondite; safe, positive overload protection; and a brand-new, heavy-duty, totally-enclosed fan motor.

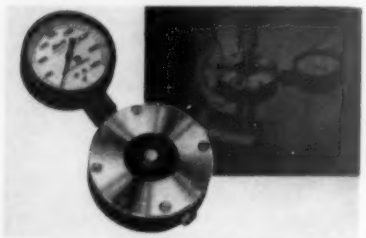
All this is further evidence that you can be sure . . . if it's Westinghouse. Only Westinghouse offers this welding leadership. Watch Westinghouse for still further developments in welding progress. J-21960

WATCH WESTINGHOUSE

where **BIG** *things are happening for* **YOU**

Direct Reading Force Gage

The Webster Force Gage is a new hydraulic type designed to measure the force between electrodes on spot-welding machines, or between rolls on roll welders.



The hydraulic unit features an insulated contact surface, preventing damage from accidental firing of welding equipment while taking force measurements. Its use enables duplication of correct electrode pressure for any job without numerous sample welds.

Complete information is available from Webster Instrument, Inc., 11856 Mississippi Ave., Los Angeles 25, Calif.

Powdered-Metal Low-Hydrogen Electrode

A new powdered-metal low-hydrogen electrode, said to be faster in lineal speed by up to 30% than conventional low-hydrogen electrodes, has been announced by the General Electric Co.'s Welding Department.

Designated Strikeasy LH-2, the new electrode is a gray, heavy coated, low-hydrogen electrode with powdered metal added to the coating. It meets the mechanical requirements of AWS Class E-7016.

Recommended for use with d-c reverse current, the new electrode can also be used with a-c current. Ultimate tensile strength, as welded, is rated at 80–83,000 psi, yield strength at 70–73,000 psi with elongation of 34% in a 2-in. specimen. Impact tests indicate that the deposit, as-welded, undergoes a transition from ductile to brittle frac-

WESTINGHOUSE SAVES $18,043 with USS "T-1" STEEL

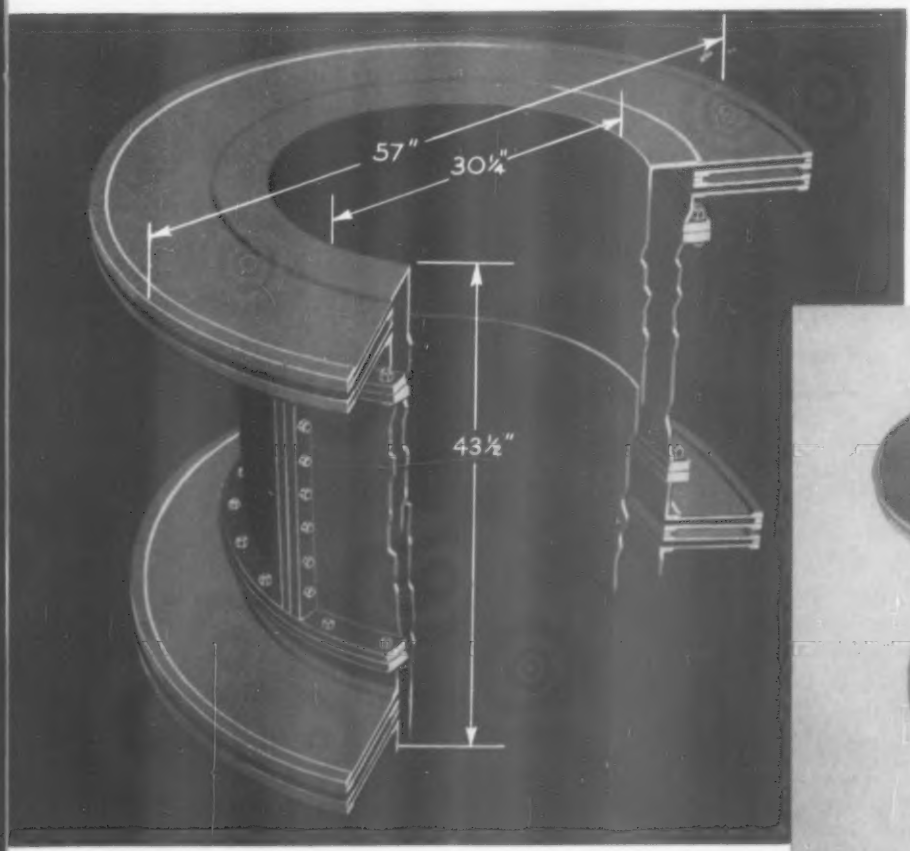
The Sunnyvale, California, plant of Westinghouse Electric Corporation builds unusual expansion bellows and huge wind tunnel air compressors. Steel bellows that flex, both up-and-down and sideways, form a means of effectively accommodating large thermal expansions between the compressor and the foundation. Westinghouse lopped an impressive $18,043 off the cost of these bellows by switching to USS "T-1" Steel.

"T-1" costs less to machine. It costs less to weld. To top it off, "T-1" *costs less to buy* than the steel previously used. Yet it is plenty tough and strong enough to meet the rugged physical requirements.

NEW WAYS TO SAVE MONEY

No other alloy steel can be used in *so many ways* to save money or improve products. Already—and "T-1" is still a relatively new steel—it has been used with great success in rotating machines, earth-moving equipment, towers, pressure vessels, mining machines, printing presses, and other heavy-duty applications.

Think of USS "T-1" when *you* need very high tensile strength (105,000 psi.) and yield strength (90,000 psi.) . . . when you need good creep rupture strength at high temperatures . . . extraordinary toughness at sub-zero temperatures . . . resistance to abrasion, impact, and abuse. All or any of these properties, plus good weldability, are yours in "T-1"! For information write to United States Steel, Room 5328, Pittsburgh 30, Pa.



A CUSHION OF STEEL. Here is one of the bellow systems that are used on large wind tunnel air compressors. Two steel bellows at the top and at the bottom of the central cylindrical section flex, both up-and-down and sideways, to provide a means of accommodating large thermal expansions for the huge compressors. Tough, strong steel was needed for the bellows. USS "T-1" does the job better and, at the same time, saves money for the Westinghouse Electric Corporation.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL

We all can't get into the ad

but here are four of our family of 25 FLUXINES. 50 years of scientific research enables us to give you the particular FLUXINE you need.

"Complete line of "KOP-R-ARC" coated rods for welding copper and all copper alloys."

NO. 43 FLUXINE —non-glaring for low melting silver solders on stainless steel, iron, inconel, etc. No injurious fumes.

NO. 7 FLUXINE —for welding all types of aluminum, aluminum alloys and Dow Metal.

NO. 4 FLUXINE —for brazing—welding—cast iron with bronze rods. Smooth strong joints.

NO. 88 FLUXINE —concentrated fluid with powerful cleansing—for soft soldering.

Write on company letterhead for chart and generous sample stating which FLUXINE desired. Inquiries from jobbers invited.

KREMBS & COMPANY
(Est. 1875)
Dept W, 669 W. Ohio St., Chicago 10, Ill.

ture below −40° F, according to company engineers, giving the LH-2 impact properties suitable for most applications.

For additional details write to Welding Department, General Electric Co., York, Pa.

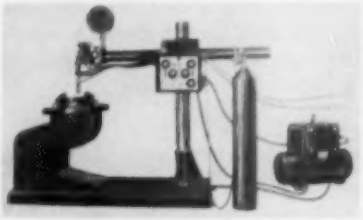
E-6014 Electrodes

"Rocket 14" is Hobart's newest iron-powder type electrode and is designed for a-c or d-c operation in all positions. The iron powder in the coating permits welding at higher currents to increase deposition rates over conventional E-6014 type electrodes.

According to manufacturer, the arc is soft and stable in all positions, and there is no tendency to stick on either ac or dc. The contour of the weld is easily controlled by the arc length, a short arc increases the convexity and a long arc decreases the convexity. The weld bead is smooth, slag is easily removed and there is very little splatter. Hobart "Rocket 14" comes in $^{3}/_{32}$-, $^{1}/_{8}$-, $^{5}/_{32}$-, $^{3}/_{16}$-, $^{7}/_{32}$-, $^{1}/_{4}$- and $^{5}/_{16}$-in. sizes. For complete details, write to Hobart Brothers Co., Troy, Ohio.

Automatic Welding Unit

A new automatic consumable-electrode inert-gas shielded-arc welding unit is announced by Hobart Brothers Co., Troy, Ohio, for use with their new constant voltage "Powromatic" welder. It can be mounted on a stationary fixture with the work traveling, or on a traveling fixture with the work in a stationary position.



Two models are available: Model AIG-4D is a dual-control type complete with a double-swing welding head, gas and water supply facilities, dual-control panel, wire reel and spool adapter. Model AIG-4T is a triple-control type which includes the same essential components as the Model AIG-4D, plus an additional travel motor speed control in the control panel.

Argon, helium or carbon dioxide may be used as a shielding gas and by using different sizes of wire-feed rolls and guides, and different gear box ratios it is possible to use either model with hard wires 0.035 to $^{1}/_{8}$ in. or soft wires 0.045 to $^{3}/_{32}$ in.

For complete details, write directly to manufacturer.

Portable Spot Arc Gun

A new portable spot arc welding gun to simplify and speed automobile body repair and sheet metal fabrication is being manufactured and distributed by the Spot Arc Gun Sales Co. of Cleveland, Ohio.

Weighing only 2 lb and constructed with a strong plastic body, the gun is insulated and shockproof. The automatic trigger feed will produce 15 to 18 spots per 9 in. of $^{5}/_{64}$- or $^{3}/_{32}$-diam welding rod.

During continuous welding operations, the gun barrel can be cooled simply by dipping it into water. Four or five rods can be used before such cooling is necessary.

Detailed literature can be obtained by writing to the Spot Arc Gun Sales Co., 14689 Euclid Ave., Cleveland 12, Ohio.

Inco Announces New Ni-O-Nel Electrode and Filler Wire

Two new welding products recently developed at the Bayonne Research Laboratory of the International Nickel Co. now make it possible to weld Ni-o-nel, a nickel-iron-chromium alloy. The products are "135" Ni-o-nel electrode and "65" Ni-o-nel filler wire and rod.

According to the manufacturer, the electrode and filler wire rod enable the welder to lay a sound, high-quality bead. Both products give X-ray quality welds and allow operation in all positions. The welds have corrosion resistance and strength equal to that of the base metal itself.

Made in four convenient diameters, $^{3}/_{32}$, $^{1}/_{8}$, $^{5}/_{32}$, and $^{3}/_{16}$ in., the "135" Ni-o-nel electrodes come in 14-in. lengths.

The "65" Ni-o-nel filler wire is produced in diameters of 0.035, 0.045, and 0.062 in., on disposable spools for inert-gas metal-arc welding process. Produced in 36-in. straightened and cut lengths for tungsten-arc process, it is available in 5 diameters: $^{3}/_{15}$, $^{5}/_{32}$, $^{1}/_{8}$, $^{3}/_{32}$, and $^{1}/_{16}$ in.

Ni-o-nel, which was released by Inco to the trade in April 1955, is a high-nickel alloy containing approximately 40% nickel, 21% chromium, 3% molybdenum, 1.75% copper, 31% iron and small amounts of manganese, silicon and carbon.

For additional information, write to International Nickel Co., 67 Wall St., New York 5, N. Y.

High-Silver Brazing Alloy

Eutec-SilWeld 1618, a new high-silver content alloy blended with special flux in convenient "paint-on" paste form is now available from Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N. Y.

The new Eutec-SilWeld 1618 is recommended for preplacement, tinning, filling, overlaying and joining. It is intended to eliminate the need for costly rings, shims and strips. It is applied with brush or spatula and flows readily by capillary action.

According to the manufacturer, Eutec-SilWeld 1618 is ideal in every shop doing silver soldering or silver brazing. It may be used on all metals except aluminum, magnesium and white metals and is applicable for torch, furnace, induction or resistance heating.

For more information request free folder TIS 2406 from Technical Information Service, Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N. Y.

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Cut Lengths... straightened and cut wire furnished in 36" lengths for inert arc and gas welding.

Sizes: .035", .045", 1/16", 5/64", 3/32", 1/8", 5/32", 3/16" and 1/4" diameters.

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NEW LITERATURE

Carbon Dioxide Welding

The Liquid Carbonic Corp., 3100 S. Kedzie Ave., Chicago 23, Ill., announces the availability of their publication "Metallic-Arc Gas-Shielded Welding with Carbon Dioxide." Free copies may be obtained by writing directly to the above address or to your nearest Liquid Carbonic District office.

Postweld Heat Treatment

The Tubular Products Division of the Babcock & Wilcox Co. has recently issued a 12-page pamphlet entitled "Heat Treatment of Air Hardening Alloys on Welding."

This illustrated folder furnishes the metallurgical data compiled from exhaustive studies on the subject of postweld heat treatment and the influence of weld preheating temperature on hardness and microstructure of heat treated welds of air hardening alloys.

Copies of this bulletin, known as TR-543, can be obtained free upon request at the division's general offices in Beaver Falls, Pa.

Resistance Welding

Sciaky Bros., Inc., 4915 W. 67th St., Chicago, Ill., introduce Vol. 4, No. 8, "Resistance Welding at Work." This issue discloses how Grumman Aircraft Engineering Corp. of Bethpage, L. I., designed and resistance welded the integral leading edge, wing fuel tank for the U. S. Navy's F9F-8 Cougar Jet.

This 8-page publication is well illustrated with specification drawings and numerous photographs revealing seven sequence steps of production assembly with its related tooling. A technical discussion accompanies each step. Other sections are devoted to design considerations, testing for leaks, etc.

For your free copy of resistance welding the leading edge, wing fuel tank, write direct to the Chicago Plant for Vol. 4, No. 8, Dept. L-7.

Piping Identification Standard

The American Society of Mechanical Engineers announces the issuance of a new edition of American Standard, *Scheme for the Identification of Piping Systems*, A 13.1—1956.

Methods for identification of the contents of piping systems have been in use since 1908. In the beginning color was used as the primary means of identification. However, with the increase in the number of materials conveyed by piping, there was created confusion between similar colors; also the fact that a material might be safe for one use, but hazardous for another and other similar considerations added to the complexity. It is now agreed that positive identification of the contents of a piping system must be by lettered legend specifically giving the name of the content in full or abbreviated form. Provision is made for use of color as a supplementary means of identification, where this is considered desirable.

Price is $1.00 per copy. Write to American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

Solder Alloy Chart

Quick reference to the melting points of all solder alloys, rising from the fusible at 136° F to the silver solder or brazing range at 1300° F, is provided by a new bulletin prepared by the Anchor Metal Co., Inc., 244 Boerum St., Brooklyn 6, N. Y.

The selection chart contains the drawing of a thermometer and lists the company's line of solder alloys beside the temperatures at which they melt. The chart includes solders containing tin, lead, antimony, indium, silver, cadmium, aluminum, zinc, die cast and bismuth. Also included is a breakdown of the industrial uses for each solder.

Free copies of the selection chart are available from the manufacturer on request.

Welding Processes

A new 16-page "Picture Book of Facts on Eutectic's Welding Processes" (TIS 2367) available free from Technical Information Service, Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N. Y., gives purchasing agents, shop foremen and welders helpful information on the "low-heat input" metal-joining process.

The book tells how to use Eutectic's District Engineer field service and describes its "low-heat input" process which combines the advantages of the low-application heats of brazing with the greater strength of fusion welding.

Magnesium Nomenclature

The Magnesium Association recently issued a 12-page pamphlet titled, "Magnesium Base Alloys, Alloy Nomenclature and Temper Designation." The booklet is identified by the Association as "an effort to arrive at a common system of alloy designations for use on prints and by purchasing agents."

In describing the booklet, the Association points out that the data incorporated in the standard alloy nomenclature and temper designations is that which has been adopted by the American Society for Testing Materials.

Alloy Nomenclature is covered by ASTM Specification B275-53T, Codification of Light Metals and Alloys, Cast and Wrought. Temper Designations are covered by ASTM Specification B296-54T, Temper Designation of Light Metals and Alloys, Cast and Wrought. Copies of The Magnesium Association booklet are available from the offices of the Association, 122 E. 42nd St., New York 17.

INSTRUCTIONS FOR PROSPECTIVE AUTHORS

Authors who plan to submit papers for publication in THE WELDING JOURNAL are invited to send for a free copy of the booklet "Instructions and Suggestions for Author." All requests should be addressed to Editor, The Welding Journal, American Welding Society, 33 W. 39th St., New York 18, N. Y.

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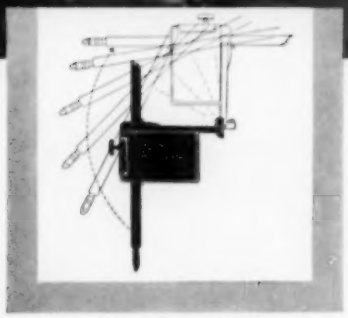

New Airco Model C Heliweld automatic head operates at all angles from horizontal to vertical.

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The Model C Heliweld automatic head is specifically designed for long-run production on regular or irregular contours – aluminum tubing, motor stators, irregularly-shaped pressure vessels. Its prime advantage is that once the required arc length is set the head will automatically maintain this distance by moving the holder up or down to follow the contours of the work piece. Other benefits are:

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The use of the new automatic head will be required where welds of consistent dimensions and quality are important and where good weld appearance is necessary or where welding specifications are very high for the electrical, aircraft, and refrigeration industries. Complete information covering the wide range of applications and detailed specification data is available. Write Airco at the first opportunity.

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